Gratitude

In appreciation and gratitude

to The Custodian of the Two Holy Mosques

King Abdullah Bin Abdul Aziz Al Saud

And

H.R.H. Prince Sultan Bin Abdul Aziz Al Saud

Crown Prince, Deputy Premier, Minister of Defence

& Aviation and Inspector General

For their continuous support and gracious consideration,

the Saudi Building Code National Committee (SBCNC)

is honored to present the first issue of

the Saudi Building Code (SBC).

Saudi Building Code Requirements

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PREFACE

The Saudi Building Code (SBC) is a set of legal, administrative and technical regulations and requirements that specify the minimum standards of construction for building in order to ensure public safety and health. A Royal Decree dated 11th June 2000 order the formation of a national committee composed of representatives of Saudi universities and governmental and private sectors. In September 2001, the Council of Ministers approved the general plan of the National Committee to develop a national building code for the Kingdom of Saudi Arabia.

To choose a base code for the Saudi Building Code, a number of Codes have been studied. The National Committee has been acquainted with the results of the national researches and the international codes from the U.S.A., Canada and Australia, also, the European Code, and Arab Codes. It has also sought the opinions of specialists in relevant Saudi universities, governmental and private sectors through holding a questionnaire, a symposium and specialized workshops, in the light of which, (ICC) has been chosen to be a base code for the Saudi Building Code.

The International Code Council (ICC) grants permission to the Saudi Building Code National Committee (SBCNC) to include all or any portion of material from the ICC codes, and standards in the SBC and ICC is not responsible or liable in any way to SBCNC or to any other party or entity for any modifications or changes that SBCNC makes to such documents.

Toward expanding the participation of all the specialists in the building and construction industry in the Kingdom through the governmental and private sectors, the universities and research centers, the National Committee took its own decisions related to code content by holding specialized meetings, symposiums and workshops and by the help of experts from inside and outside of Saudi Arabia.

The technical committees and sub-committees started their work in April 2003 to develop the Saudi Building Code that adapts the base code with the social and cultural environment, the natural and climatic conditions, types of soil and properties of materials in the Kingdom.

The Saudi Building Code Energy Conservation Requirements (SBC 601) was based on the *International Energy Conservation Code* (IECC).

The development process of SBC 601 followed the methodology approved by the Saudi Building Code National Committee. Many changes and modifications were made on the base code and only SI units were used throughout the Code. The changes were intended to compose a comprehensive set of provisions, to the best possible extent, for materials, environmental conditions, and construction practices prevailing in the Kingdom.

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DEFINITIONS

ACCESSIBLE (AS APPLIED TO EQUIPMENT). Admitting close approach because not guarded by locked doors, elevation or other effective means (see "Readily accessible").

ADDITION. An extension or increase in the height, conditioned floor area or conditioned volume of a building or structure.

AIR TRANSPORT FACTOR. The ratio of the rate of useful sensible heat removal from the conditioned space to the energy input to the supply and return fan motor(s), expressed in consistent units and under the designated operating conditions.

ALTERATION. Any construction, renovation or change in a mechanical system that involves an extension, addition or change to the arrangement, type or purpose of the original installation.

ANNUAL FUEL UTILIZATION EFFICIENCY (AFUE). The ratio of annual output energy to annual input energy which includes any nonheating season pilot input loss, and for gas or oil-fired furnaces or boilers, does not include electrical energy.

APPROVED. Approved by the code official or other authority having jurisdiction as the result of investigation and tests conducted by said official or authority, or by reason of accepted principles or tests by nationally recognized organizations.

AUTOMATIC. Self-acting, operating by its own mechanism when actuated by some impersonal influence, as, for example, a change in current strength, pressure, temperature or mechanical configuration (see "Manual").

BASEMENT WALL. The opaque portion of a wall which encloses one side of a basement and having an average below-grade area greater than or equal to 50 percent of its total wall area, including openings (see "Gross area of exterior walls").

BTU. Abbreviation for British thermal unit, which is the quantity of heat required to raise the temperature of 0.454 kg (1 pound) of water Δ 0.56°C (1°F), (1 Btu = 1,055 J).

BUILDING. Any structure occupied or intended for supporting or sheltering any use or occupancy.

BUILDING ENVELOPE. The elements of a building which enclose conditioned spaces through which thermal energy is capable of being transferred to or from the exterior or to or from spaces exempted by the Saudi Building Code.

CODE OFFICIAL. The officer or other designated authority charged with the administration and enforcement of this code, or a duly authorized representative.

COEFFICIENT OF PERFORMANCE (COP)—COOLING. The ratio of the rate of heat removal to the rate of energy input in consistent units, for a complete cooling system or factory-assembled equipment, as tested under a nationally recognized standard or designated operating conditions.

COEFFICIENT OF PERFORMANCE (COP)—HEAT PUMP—HEATING. The ratio of the rate of heat delivered to the rate of energy input, in consistent units, for a complete heat pump system under designated operating conditions. Supplemental heat shall not be

considered when checking compliance with the heat pump equipment (COPs listed in the tables in Sections 4.3 and 6.3).

COMFORT ENVELOPE. The areas defined on a psychrometric chart and enclosing the range of operative temperatures and humidities for both the winter and summer comfort zones as depicted in Figure 2 of ASHRAE 55.

COMMERCIAL BUILDING. All buildings other than detached one- and two-family dwellings, townhouses and residential buildings, Groups R-2 and R-4.

CONDENSER. A heat exchanger designed to liquefy refrigerant vapor by removal of heat.

CONDENSING UNIT. A specific refrigerating machine combination for a given refrigerant, consisting of one or more power-driven compressors, condensers, liquid receivers (when required), and the regularly furnished accessories.

CONDITIONED FLOOR AREA. The horizontal projection of that portion of interior space which is contained within exterior walls and which is conditioned directly or indirectly by an energy-using system.

CONDITIONED SPACE. A heated or cooled space, or both, within a building and, where required, provided with humidification or dehumidification means so as to be capable of maintaining a space condition falling within the comfort envelope set forth in ASHRAE 55.

COOLED SPACE. Space within a building which is provided with a positive cooling supply (see “Positive cooling supply”).

CRAWL SPACE WALL. The opaque portion of a wall which encloses a crawl space and is partially or totally below grade.

DEAD BAND. The temperature range in which no heating or cooling is used.

DEGREE DAY, COOLING. A unit, based on temperature difference and time, used in estimating cooling energy consumption and specifying nominal cooling load of a building in summer. For any one day, when the mean temperature is more than 18°C (65°F), there are as many degree days as there are degrees Fahrenheit (Celsius) difference in temperature between the mean temperature for the day and 18°C (65°F). Annual cooling degree days (CDD) are the sum of the degree days over a calendar year.

DEGREE DAY, HEATING. A unit, based on temperature difference and time, used in estimating heating energy consumption and specifying nominal heating load of a building in winter. For any one day, when the mean temperature is less than 18°C (65°F), there are as many degree days as there are degrees Fahrenheit (Celsius) difference in temperature between the mean temperature for the day and 18°C (65°F). Annual heating degree days (HDD) are the sum of the degree days over a calendar year.

DUCT. A tube or conduit utilized for conveying air. The air passages of self-contained systems are not to be construed as air ducts.

DUCT SYSTEM. A continuous passageway for the transmission of air that, in addition to ducts, includes duct fittings, dampers, plenums, fans and accessory air-handling equipment and appliances.

DWELLING UNIT. A single housekeeping unit comprised of one or more rooms providing complete independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking and sanitation.

ECONOMIZER. A ducting arrangement and automatic control system that allows a cooling supply fan system to supply outdoor air to reduce or eliminate the need for mechanical refrigeration during mild or cold weather.

ENERGY. The capacity for doing work (taking a number of forms) which is capable of being transformed from one into another, such as thermal (heat), mechanical (work), electrical and chemical in customary units, measured in joules (J), kilowatt-hours (kWh) or British thermal units (Btu).

ENERGY ANALYSIS. A method for determining the annual (8,760 hours) energy use of the proposed design and standard design based on hour-by-hour estimates of energy use.

ENERGY COST. The total estimated annual cost for purchased energy for the building, including any demand charges, fuel adjustment factors and delivery charges applicable to the building.

ENERGY EFFICIENCY RATIO (EER). The ratio of net equipment cooling capacity in British thermal units per hour (Btu/h) to total rate of electric input in watts under designated operating conditions. When consistent units are used, this ratio becomes equal to COP (see also "Coefficient of performance").

EVAPORATOR. That part of the system in which liquid refrigerant is vaporized to produce refrigeration.

EXTERIOR ENVELOPE. See "Building envelope."

EXTERIOR WALL. An above-grade wall enclosing conditioned space which is vertical or sloped at an angle 60 degrees (1.1 rad) or greater from the horizontal (see "Roof assembly"). Includes between-floor spandrels, peripheral edges of floors, roof and basement knee walls, dormer walls, gable end walls, walls enclosing a mansard roof, and basement walls with an average below-grade wall area which is less than 50 percent of the total opaque and non opaque area of that enclosing side.

FENESTRATION. Skylights, roof windows, vertical windows (whether fixed or moveable), opaque doors, glazed doors, glass block, and combination opaque/glazed doors.

FURNACE, DUCT. A furnace normally installed in distribution ducts of air-conditioning systems to supply warm air for heating and which depends on a blower not furnished as part of the duct furnace for air circulation.

FURNACE, WARM AIR. A self-contained, indirect-fired or electrically heated furnace that supplies heated air through ducts to spaces that require it.

GLAZING AREA. Total area of the glazed fenestration measured using the rough opening and including sash, curbing or other framing elements that enclose conditioned space. Glazing area includes the area of glazed fenestration assemblies in walls bounding conditioned basements. For doors where the daylight opening area is less than 50 percent of the door area, the glazing area is the daylight opening area. For all other doors, the glazing area is the rough opening area for the door including the door and the frame.

GROSS AREA OF EXTERIOR WALLS. The normal projection of all exterior walls, including the area of all windows and doors installed therein (see "Exterior wall").

GROSS FLOOR AREA. The sum of the areas of several floors of the building, including basements, cellars, mezzanine and intermediate floored tiers and penthouses of headroom height, measured from the exterior faces of exterior walls or from the centerline of walls separating buildings, but excluding:

1. Covered walkways, open roofed-over areas, porches and similar spaces.
2. Pipe trenches, exterior terraces or steps, chimneys, roof overhangs and similar features.

HEAT. The form of energy that is transferred by virtue of a temperature difference or a change in state of a material.

HEAT CAPACITY (HC). The amount of heat necessary to raise the temperature of a given mass by one degree. The heat capacity of a building element is the sum of the heat capacities of each of its components.

HEAT PUMP. A refrigeration system that extracts heat from one substance and transfers it to another portion of the same substance or to a second substance at a higher temperature for a beneficial purpose.

HEAT REJECTION EQUIPMENT. Equipment used in comfort cooling systems such as air-cooled condensers, open cooling towers, closed-circuit cooling towers and evaporative condensers.

HEAT TRAP. An arrangement of piping and fittings, such as elbows, or a commercially available heat trap, that prevents thermosyphoning of hot water during standby periods.

HEATED SLAB. Slab-on-grade construction in which the heating elements or hot air distribution system is in contact with or placed within the slab or the subgrade.

HEATED SPACE. Space within a building which is provided with a positive heat supply (see "Positive heat supply"). Finished living space within a basement with registers or heating devices designed to supply heat to a basement space shall automatically define that space as heated space.

HEATING SEASONAL PERFORMANCE FACTOR (HSPF). The total heating output of a heat pump during its normal annual usage period for heating, in Btu, divided by the total electric energy input during the same period, in watt hours, as determined by Test Procedures.

HUMIDISTAT. A regulatory device, actuated by changes in humidity, used for automatic control of relative humidity.

HVAC. Heating, ventilating and air conditioning.

HVAC SYSTEM. The equipment, distribution network, and terminals that provide either collectively or individually the processes of heating, ventilating, or air conditioning to a building.

HVAC SYSTEM COMPONENTS. HVAC system components provide, in one or more factory-assembled packages, means for chilling or heating water, or both, with controlled temperature for delivery to terminal units serving the conditioned spaces of the building.

Types of HVAC system components include, but are not limited to, water chiller packages, reciprocating condensing units and water source (hydronic) heat pumps (see “HVAC system equipment”).

HVAC SYSTEM EQUIPMENT. HVAC system equipment provides, in one (single package) or more (split system) factory-assembled packages, means for air circulation, air cleaning, air cooling with controlled temperature and dehumidification and, optionally, either alone or in combination with a heating plant, the functions of heating and humidifying. The cooling function is either electrically or heat operated and the refrigerant condenser is air, water or evaporatively cooled. Where the equipment is provided in more than one package, the separate packages shall be designed by the manufacturer to be used together. The equipment shall be permitted to provide the heating function as a heat pump or by the use of electric or fossil-fuel-fired elements. (The word “equipment” used without a modifying adjective, in accordance with common industry usage, applies either to HVAC system equipment or HVAC system components).

INFILTRATION. The uncontrolled inward air leakage through cracks and interstices in any building element and around windows and doors of a building caused by the pressure effects of wind or the effect of differences in the indoor and outdoor air density or both.

INSULATING SHEATHING. An insulating board having a minimum thermal resistance of R-2 of the core material.

INTEGRATED PART-LOAD VALUE (IPLV). A single measure of merit, based on part-load EER or COP expressing part-load efficiency for air-conditioning and heat pump equipment on the basis of weighted operation at various load capacities for the equipment.

LABELED. Devices, equipment, appliances, assemblies or materials to which have been affixed a label, seal, symbol or other identifying mark of a nationally recognized testing laboratory, inspection agency or other organization concerned with product evaluation that maintains periodic inspection of the production of the above-labeled items and by whose label the manufacturer attests to compliance with applicable nationally recognized standards.

LISTED. Equipment, appliances, assemblies or materials included in a list published by a nationally recognized testing laboratory, inspection agency or other organization concerned with product evaluation that maintains periodic inspection of production of listed equipment, appliances, assemblies or material, and whose listing states either that the equipment, appliances, assemblies, or material meets nationally recognized standards or has been tested and found suitable for use in a specified manner.

LOW-VOLTAGE LIGHTING. Lighting equipment that is powered through a transformer such as cable conductor, rail conductor and track lighting.

LUMINAIRE. A complete lighting unit consisting of at least one lamp and the parts designed to distribute the light, to position and protect the lamp, to connect the lamp to the power supply and ballasting, when applicable. Luminaires are commonly referred to as “lighting fixtures.”

MANUAL. Capable of being operated by personal intervention (see “Automatic”).

MULTIFAMILY DWELLING. A building containing three or more dwelling units.

MULTIPLE SINGLE-FAMILY DWELLING (TOWNHOUSE). A building not more than three stories in height consisting of multiple single-family dwelling units, constructed in a group of three or more attached units in which each unit extends from foundation to roof and with open space on at least two sides.

OCCUPANCY. The purpose for which a building, or portion thereof, is utilized or occupied.

OPAQUE AREAS. All exposed areas of a building envelope which enclose conditioned space, except openings for windows, skylights, doors and building service systems.

OUTDOOR AIR. Air taken from the outdoors and, therefore, not previously circulated through the system.

OZONE DEPLETION FACTOR. A relative measure of the potency of chemicals in depleting stratospheric ozone. The ozone depletion factor potential depends on the chlorine and bromine content and the atmospheric lifetime of the chemical. The depletion factor potential is normalized such that the factor for CFC-11 is set equal to unity and the factors for the other chemicals indicate their potential relative to CFC-11.

PACKAGED TERMINAL AIR CONDITIONER (PTAC). A factory-selected wall sleeve and separate unencased combination of heating and cooling components, assemblies or sections (intended for mounting through the wall to serve a single room or zone). It includes heating capability by hot water, steam or electricity. (For the complete technical definition, see ARI 310/380.)

PACKAGED TERMINAL HEAT PUMP. A PTAC capable of using the refrigeration system in a reverse cycle or heat pump mode to provide heat. (For the complete technical definition, see ARI 310/380.)

POSITIVE COOLING SUPPLY. Mechanical cooling deliberately supplied to a space, such as through a supply register. Also, mechanical cooling indirectly supplied to a space through uninsulated surfaces of space-cooling components, such as evaporator coil cases and cooling distribution systems which continually maintain air temperatures within the space of 29°C (85°F) or lower during normal operation. To be considered exempt from inclusion in this definition, such surfaces shall comply with the insulation requirements of this code.

POSITIVE HEAT SUPPLY. Heat deliberately supplied to a space by design, such as a supply register, radiator or heating element. Also, heat indirectly supplied to a space through uninsulated surfaces of service water heaters and space-heating components, such as furnaces, boilers and heating and cooling distribution systems which continually maintain air temperature within the space of 10°C (50°F) or higher during normal operation. To be considered exempt from inclusion in this definition, such surfaces shall comply with the insulation requirements of this code.

PROPOSED DESIGN. A description of the proposed building design used to estimate annual energy costs for determining compliance based on total building performance.

READILY ACCESSIBLE. Capable of being reached quickly for operation, renewal or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders or access equipment (see “Accessible”).

REFRIGERANT. A substance utilized to produce refrigeration by its expansion or vaporization or absorption.

RENEWABLE ENERGY SOURCES. Sources of energy (excluding minerals) derived from incoming solar radiation, including natural day lighting and photosynthetic processes; from phenomena resulting there from, including wind, waves and tides, lake or pond thermal differences; and from the internal heat of the earth, including nocturnal thermal exchanges.

REPAIR. The reconstruction or renewal of any part of an existing building for the purpose of its maintenance.

RESIDENTIAL BUILDING, GROUP R-2. Residential occupancies containing more than two dwelling units where the occupants are primarily permanent in nature such as apartment houses, boarding houses (not transient), convents, monasteries, rectories, fraternities and sororities, dormitories and rooming houses. For the purpose of this code, reference to Group R-2 occupancies shall refer to buildings that are three stories or less in height above grade.

RESIDENTIAL BUILDING, GROUP R-4. Residential occupancies shall include buildings arranged for occupancies as Residential Care/Assisted Living Facilities including more than five but not more than 16 occupants, excluding staff. For the purpose of this code, reference to Group R-4 occupancies shall refer to buildings which are three stories or less in height above grade.

ROOF ASSEMBLY. A roof assembly shall be considered as all roof/ceiling components of the building envelope through which heat flows, thus creating a building transmission heat loss or gain, where such assembly is exposed to outdoor air and encloses conditioned space. The gross area of a roof assembly consists of the total interior surface of all roof/ceiling components, including opaque surfaces, dormer and bay window roofs, trey ceilings, overhead portions of an interior stairway to an unconditioned attic, doors and hatches, glazing and skylights exposed to conditioned space, that are horizontal or sloped at an angle less than 60 degrees (1.1 rad) from the horizontal (see “Exterior wall”). A roof assembly, or portions thereof, having a slope of 60 degrees (1.1 rad) or greater from horizontal shall be considered in the gross area of exterior walls and thereby excluded from consideration in the roof assembly. Skylight shaft walls 305 mm (12 inches) in depth or greater (as measured from the ceiling plane to the roof deck) shall be considered in the gross area of exterior walls and are thereby excluded from consideration in the roof assembly.

ROOM AIR CONDITIONER. An encased assembly designed as a unit for mounting in a window or through a wall, or as a console. It is designed primarily to provide free delivery of conditioned air to an enclosed space, room or zone. It includes a prime source of refrigeration for cooling and dehumidification and means for circulating and cleaning air, and shall be permitted to also include means for ventilating and heating.

SASH CRACK. The sum of all perimeters of all window sashes, based on overall dimensions of such parts, expressed in feet. If a portion of one sash perimeter overlaps a portion of another sash perimeter, the overlapping portions are only counted once.

SCREW LAMPHOLDERS. A lamp base that requires a screw-in-type lamp such as an incandescent or tungsten-halogen bulb.

SEASONAL ENERGY EFFICIENCY RATIO (SEER). The total cooling output of an air conditioner during its normal annual usage period for cooling, in Btu/h, divided by the total electric energy input during the same period, in watt-hours, as determined by Test Procedures.

SERVICE SYSTEMS. All energy-using systems in a building that are operated to provide services for the occupants or processes housed therein, including HVAC, service water heating, illumination, transportation, cooking or food preparation, laundering and similar functions.

SERVICE WATER HEATING. Supply of hot water for purposes other than comfort heating.

SIMULATION TOOL. An approved software program or calculation-based methodology that projects the hour-by-hour loads and annual energy use of a building.

SKYLIGHT. Glazing that is horizontal or sloped at an angle less than 60 degrees (1.1 rad) from the horizontal (see "Glazing area").

SLAB-ON-GRADE FLOOR INSULATION. Insulation around the perimeter of the floor slab or its supporting foundation when the top edge of the floor perimeter slab is above the finished grade or 12 inches (305 mm) or less below the finished grade.

SOLAR ENERGY SOURCE. Source of natural day lighting and of thermal, chemical or electrical energy derived directly from conversion of incident solar radiation.

STANDARD DESIGN. A version of the proposed design that meets the minimum requirements of this code and is used to determine the maximum annual energy cost requirement for compliance based on total building performance.

STANDARD TRUSS. Any construction that does not permit the roof/ceiling insulation to achieve the required *R*-value over the exterior walls.

SUNROOM ADDITION. A one-story structure added to an existing dwelling with a glazing area in excess of 40 percent of the gross area of the structure's exterior walls and roof.

SYSTEM. A combination of central or terminal equipment or components or controls, accessories, interconnecting means, and terminal devices by which energy is transformed so as to perform a specific function, such as HVAC, service water heating or illumination.

THERMAL CONDUCTANCE. Time rate of heat flow through a body (frequently per unit area) from one of its bounding surfaces to the other for a unit temperature difference between the two surfaces, under steady conditions (Btu/h · ft^2 · °F) [W/(m^2 · K)].

THERMAL ISOLATION. A separation of conditioned spaces, between a sunroom addition and a dwelling unit, consisting of existing or new wall(s), doors and/or windows. New wall(s), doors and/or windows shall meet the prescriptive envelope component criteria in Table 4.2.2.5.

THERMAL RESISTANCE (*R*). The reciprocal of thermal conductance (h · ft^2 · °F/Btu) [(m^2 · K)/W].

THERMAL RESISTANCE, OVERALL (R_o). The reciprocal of overall thermal conductance (h · ft^2 · °F/Btu)[(m^2 · K)/W]. The overall thermal resistance of the gross area or individual component of the exterior building envelope (such as roof/ceiling, exterior wall, floor, crawl space wall, foundation, window, skylight, door, opaque wall, etc.), which includes the area weighted *R*-values of the specific component assemblies (such as air film, insulation, drywall, framing, glazing, etc.).

THERMAL TRANSMITTANCE (*U*). The coefficient of heat transmission (air to air). It is the time rate of heat flow per unit area and unit temperature difference between the warm-side and cold-side air films (Btu/h · ft^2 · °F) [W/(m^2 · K)]. The *U*-factor applies to combinations of different materials used in series along the heat flow path, single materials that comprise a building section, cavity airspaces and surface air films on both sides of a building element.

THERMAL TRANSMITTANCE, OVERALL (U_o). The overall (average) heat transmission of a gross area of the exterior building envelope (Btu/h · ft^2 · °F) [W/(m^2 · K)]. The U_o-factor applies to the combined effect of the time rate of heat flow through the various parallel paths, such as windows, doors and opaque construction areas, comprising the gross area of one or more exterior building components, such as walls, floors or roof/ceilings.

THERMOSTAT. An automatic control device actuated by temperature and designed to be responsive to temperature.

TOWNHOUSE. See "Multiple single-family dwelling."

UNITARY COOLING AND HEATING EQUIPMENT. One or more factory-made assemblies which include an evaporator or cooling coil, a compressor and condenser combination, and which shall be permitted to include a heating function as well. When heating and cooling equipment is provided in more than one assembly, the separate assemblies shall be designed to be used together.

UNITARY HEAT PUMP. One or more factory-made assemblies which include an indoor conditioning coil, compressor(s) and outdoor coil or refrigerant-to-water heat exchanger, including means to provide both heating and cooling functions. When heat pump equipment is provided in more than one assembly, the separate assemblies shall be designed to be used together.

VENTILATION. The process of supplying or removing air by natural or mechanical means to or from any space. Such air shall be permitted to be conditioned or unconditioned.

VENTILATION AIR. That portion of supply air which comes from outside (outdoors) plus any recirculated air that has been treated to maintain the desired quality of air within a designated space.

WATER HEATER, INSTANTANEOUS. A water heater with an input rating of at least 310 W/L (4,000 Btu/h per gallon) stored water and a storage capacity of less than 38 L (10 gallons).

WATER HEATER, STORAGE. A water heater with an input rating less than 310 W/L (4,000 Btu/h per gallon) of stored water or storage capacity of at least 38 L (10 gallons).

WINDOW PROJECTION FACTOR. A measure of the portion of glazing that is shaded by an eave or overhang.

ZONE. A space or group of spaces within a building with heating or cooling requirements, or both, sufficiently similar so that comfort conditions can be maintained throughout by a single controlling device.

CHAPTER 1
GENERAL REGULATIONS

SECTION 1.1
GENERAL

1.1.1 **Title.** These regulations shall be known as the Saudi Building Code Energy Conservation Requirements SBC 601 and shall be cited as such. It is referred to herein as "these requirements."

1.1.2 **Scope.** These Requirements establish minimum prescriptive and performance-related regulations for the design of energy-efficient buildings and structures or portions thereof that provide facilities or shelter for public assembly, educational, business, mercantile, institutional, storage and residential occupancies, as well as those portions of factory and industrial occupancies designed primarily for human occupancy. These Requirements thereby addresses the design of energy-efficient building envelopes and the selection and installation of energy-efficient mechanical, service water-heating, electrical distribution and illumination systems and equipment for the effective use of energy in these buildings and structures.

Exception: Energy conservation systems and components in existing buildings undergoing repair, alteration or additions, and change of occupancy, shall be permitted to comply with the Saudi Building Code Existing Building Requirements.

1.1.2.1 **Exempt buildings.** Buildings and structures indicated in Sections 1.1.2.1.1 and 1.1.2.1.2 shall be exempt from the building envelope provisions of these Requirements, but shall comply with the provisions for building, mechanical, service water heating and lighting systems.

1.1.2.1.1 **Separated buildings.** Buildings and structures, or portions thereof separated by building envelope assemblies from the remainder of the building, that have a peak design rate of energy usage less than 10.7 W/m^2 or 1.0 watt per square foot 10.7 W/m^2 of floor area for space conditioning purposes.

1.1.2.1.2 **Unconditioned buildings.** Buildings and structures or portions thereof which are neither heated nor cooled.

1.1.2.2 **Applicability.** The provisions of these Requirements shall apply to all matters affecting or relating to structures and premises, as set forth in Section 1.1. Where, in a specific case, different sections of these Requirements specify different materials, methods of construction or other requirements, the most restrictive shall govern.

1.1.2.2.1 **Existing installations.** Except as otherwise provided for in this chapter, a provision in these Requirements shall not require the removal, alteration or abandonment of, nor prevent the continued utilization and maintenance of, an existing building envelope, mechanical, service water-heating, electrical distribution or illumination system lawfully in existence at the time of the adoption of these Requirements.

1.1.2.2.2 **Additions, alterations or repairs.** Additions, alterations, renovations or repairs to a building envelope, mechanical, service water-heating, electrical distribution or illumination system or portion thereof shall conform to the provisions of these Requirements as they relate to new construction without requiring the unaltered portion(s) of the existing system to comply with all of these Requirements. Additions, alterations or repairs shall not cause any one of the aforementioned and existing systems to become unsafe, hazardous or overloaded.

1.1.2.2.3 **Historic buildings.** The provisions of these Requirements relating to the construction, alteration, repair, enlargement, restoration, relocation or movement

of buildings or structures shall not be mandatory for existing buildings or structures specifically identified and classified as historically.

1.1.2.2.4 **Change in occupancy.** It shall be unlawful to make a change in the occupancy of any building or structure which would result in an increase in demand for either fossil fuel or electrical energy supply unless such building or structure is made to comply with these Requirements.

1.1.2.3 **Mixed occupancy.** When a building houses more than one occupancy, each portion of the building shall conform to the requirements for the occupancy housed therein. Where minor accessory uses do not occupy more than 10 percent of the area of any floor of a building, the major use shall be considered the building occupancy. Buildings, other than detached one- and two-family dwellings and townhouses, with a height of four or more stories above grade shall be considered commercial buildings for purposes of these Requirements, regardless of the number of floors that are classified as residential occupancy.

1.1.3 **Intent.** The provisions of these Requirements shall regulate the design of building envelopes for adequate thermal resistance and low air leakage and the design and selection of mechanical, electrical, service water-heating and illumination systems and equipment which will enable effective use of energy in new building construction. It is intended that these provisions provide flexibility to permit the use of innovative approaches and techniques to achieve effective utilization of energy. These Requirements is not intended to abridge safety, health or environmental requirements under other applicable codes or ordinances.

1.1.4 **Compliance.** Compliance with these Requirements shall be determined in accordance with Sections 1.1.4.1 and 1.1.4.2.

1.1.4.1 **Residential buildings.** For residential buildings the following shall be used as the basis for compliance assessment: a systems approach for the entire building (Chapter 3) , an approach based on performance of individual components of the building envelope (Chapter 4), an approach based on performance of the total building envelope (Chapter 4), an approach based on acceptable practice for each envelope component (Chapter 4), an approach by prescriptive specification for individual components of the building envelope (Chapter 4), or an approach based on simplified, prescriptive specification (Chapter 5) where the conditions set forth in Section 1.1.4.1.1 or 1.1.4.1.2 are satisfied.

1.1.4.1.1 **Detached one- and two-family dwellings.** When the glazing area does not exceed 15 percent of the gross area of exterior walls.

1.1.4.1.2 **Residential buildings, Group R-2, R-4 or townhouses.** When the glazing area does not exceed 25 percent of the gross area of exterior walls.

1.1.4.2 **Commercial buildings.** For commercial buildings, the approach as specified by acceptable practice (Chapter 6) shall be used as the basis for compliance assessment.

SECTION 1.2
MATERIALS, SYSTEMS AND EQUIPMENT

1.2.1 **General.** Materials, equipment and systems shall be identified in a manner that will allow a determination of their compliance with the applicable provisions of these Requirements.

1.2.2 **Materials, equipment and systems installation.** All insulation materials, caulking and weather stripping, fenestration assemblies, mechanical equipment

and systems components, and water-heating equipment and system components shall be installed in accordance with the manufacturer's installation instructions.

1.2.3 **Maintenance information.** Required regular maintenance actions shall be clearly stated and incorporated on a readily accessible label. Such label shall include the title or publication number, the operation and maintenance manual for that particular model and type of product. Maintenance instructions shall be furnished for equipment that requires preventive maintenance for efficient operation.

1.2.4 **Insulation installation.** Roof/ceiling, floor, wall cavity and duct distribution systems insulation shall be installed in a manner that permits inspection of the manufacturer's *R*-value identification mark.

1.2.4.1 **Protection of exposed foundation insulation.** Insulation applied to the exterior of foundation walls and around the perimeter of slab-on-grade floors shall have a rigid, opaque and weather-resistant protective covering to prevent the degradation of the insulation's thermal performance. The protective covering shall cover the exposed area of the exterior insulation and extend a minimum of 150 mm below grade.

1.2.5 **Identification.** Materials, equipment and systems shall be identified in accordance with Sections 1.2.5.1, 1.2.5.2 and 1.2.5.3.

1.2.5.1 **Building envelope insulation.** A thermal resistance (*R*) identification mark shall be applied by the manufacturer to each piece of building envelope insulation 300 mm or greater in width. Alternatively, the insulation installer shall provide a signed and dated certification for the insulation installed in each element of the building envelope, listing the type of insulation installations in roof/ceilings, the manufacturer and the *R*-value. For blown-in or sprayed insulation, the installer shall also provide the initial installed thickness, the settled thickness, the coverage area and the number of bags installed. Where blown-in or sprayed insulation is installed in walls, floors and cathedral ceilings, the installer shall provide a certification of the installed density and *R*-value. The installer shall post the certification in a conspicuous place on the job site.

1.2.5.1.1 **Roof/ceiling insulation.** The thickness of roof/ceiling insulation that is either blown in or sprayed shall be identified by thickness markers that are labeled in inches or millimeters installed at least one for every 28 m^2 throughout the attic space. The markers shall be affixed to the trusses or joists and marked with the minimum initial installed thickness and minimum settled thickness with numbers a minimum of 25 mm in height. Each marker shall face the attic access. The thickness of installed insulation shall meet or exceed the minimum initial installed thickness shown by the marker.

1.2.5.2 **Fenestration product rating, certification and labeling.** *U*-factors of fenestration products (windows, door sand skylights) shall be determined in accordance with (NFRC 100) by an accredited, independent laboratory, and labeled and certified by the manufacturer. The solar heat gain coefficient (SHGC) of glazed fenestration products (windows, glazed doors and skylights) shall be determined in accordance with (NFRC 200) by an accredited, independent laboratory, and labeled and certified by the manufacturer. Where a shading coefficient for a fenestration product is used, it shall be determined by converting the product's SHGC, as determined in accordance with (NFRC 200), to a shading coefficient, by dividing the SHGC by 0.87. Such certified and labeled *U*-factors and SHGCs shall be accepted for purposes of determining compliance with the building envelope requirements of SBC 601.

When a manufacturer has not determined product *U*-factor in accordance with (NFRC 100) for a particular product line, compliance with the building envelope requirements of SBC 601 shall be determined by assigning such products a default *U*-factor in accordance with Tables 1.2.5.2(1) and 1.2.5.2(2). When a SHGC or shading coefficient is used for code compliance and a manufacturer has not determined product SHGC in accordance with (NFRC 200) for a particular product line, compliance with the building envelope requirements of SBC 601 shall be determined by assigning such products a default SHGC in accordance with Table 1.2.5.2(3). Product features must be verifiable for the product to qualify for the default value associated with those features. Where the existence of a particular feature cannot be determined with reasonable certainty, the product shall not receive credit for that feature. Where a composite of materials from two different product types is used, the product shall be assigned the higher *U*-factor.

TABLE 1.2.5.2(1)
***U*-FACTOR DEFAULT TABLE FOR WINDOWS, GLAZED DOORS AND SKYLIGHTS**

Frame Material and Product Type[a]	Single Glazed	Double Glazed
Metal without thermal break:		
Curtain wall	6.9	4.5
Fixed	6.4	3.9
Garden window	14.5	10
Operable (including sliding and swinging glass doors)	7.2	5
Site-assembled sloped/overhead glazing	7.7	4.7
Skylight	11	7.4
Metal with thermal break:		
Curtain wall	6.3	3.9
Fixed	6	3.6
Operable (including sliding and swinging glass doors)	6.1	3.7
Site-assembled sloped/overhead glazing	7	4
Skylight	11	6.3
Reinforced vinyl/metal clad wood:		
Fixed	5.5	3.2
Operable (including sliding and swinging glass doors)	5	3.2
Skylight	10	6
Wood/vinyl/fiberglass:		
Fixed	5.5	3.2
Garden window	13	9
Operable (including sliding and swinging glass doors)	5	3
Skylight	8.3	4.8

a. Glass-block assemblies with mortar but without reinforcing or framing shall have a *U*-factor of 3.4 $w/m^2.K$.

TABLE 1.2.5.2(2)
U-FACTOR DEFAULT TABLE FOR NONGLAZED DOORS

Door Type	With Foam Core	Without Foam Core
Steel doors (45 mm thick)	2	3.4
	With Storm Door	**Without Storm Door**
Wood doors (45 mm thick)		
Hollow core flush	1.8	2.6
Panel with 12 mm-panels	2	3
Panel with 29 mm-panels	1.6	2.2
Solid core flush	1.5	2.3

TABLE 1.2.5.2(3)
SHGC DEFAULT TABLE FOR FENESTRATION

Product Description	Single Glazed				Double Glazed			
	Clear	Bronze	Green	Gray	Clear + Clear	Bronze + Clear	Green + Clear	Gray + Clear
Metal frames								
Fixed	0.78	0.67	0.65	0.64	0.68	0.57	0.55	0.54
Operable	0.75	0.64	0.62	0.61	0.66	0.55	0.53	0.52
Nonmetal frames								
Fixed	0.75	0.64	0.62	0.61	0.66	0.54	0.53	0.52
Operable	0.63	0.54	0.53	0.52	0.55	0.46	0.45	0.44

1.2.5.3 **Duct distribution systems insulation.** A thermal resistance (*R*) identification mark shall be applied by the manufacturer in maximum intervals of no greater than 3.0 m to insulated flexible duct products showing the thermal performance *R*-value for the duct insulation itself (excluding air films, vapor retarders or other duct components).

SECTION 1.3
ALTERNATE MATERIALS – METHOD OF CONSTRUCTION, DESIGN OR INSULATING SYSTEMS

1.3.1 **General.** The provisions of these Requirements are not intended to prevent the use of any material, method of construction, design or insulating system not specifically prescribed herein, provided that such construction, design or insulating system has been approved by the code official as meeting the intent of the code. Compliance with specific provisions of these Requirements shall be determined through the use of computer software, worksheets, compliance manuals and other similar materials when they have been approved by the code official as meeting the intent of these Requirements.

CHAPTER 2
DESIGN CONDITIONS

SECTION 2.1
GENERAL

2.1.1 **Design criteria.** The criteria of this chapter establish the design conditions for use with Chapters 3, 4, 5, and 6.

SECTION 2.2
THERMAL DESIGN PARAMETERS

2.2.1 **Exterior design conditions.** The following design parameters in Table 2.2.1 shall be used for calculations required under this requirement.

TABLE 2.2.1
OUTDOOR DESIGN CONDITIONS

Condition	Value
Winter [a], Design Dry-bulb (°C)	
Summer [a], Design Dry-bulb (°C)	
Summer [a], Design Wet-bulb (°C)	
Degree days [b]	

a. The outdoor design temperature shall be selected from the columns of 97.5 percent values for winter and 2.5 percent values for summer from tables in the ASHRAE *Fundamentals Handbook*. Adjustments shall be permitted to reflect local climates which differ from the tabulated temperatures, or local weather experience determined by the code official.

b. The degree days (base 18°C) shall be selected from the DD values shown in Table 2.2.2 which were calculated from the 1993-2003 Data of the Meteorology & Environmental Protection Administration, Saudi Arabia.

TABLE 2.2.2
DEGREE DAYS FOR METEOROLOGICAL STATIONS OF KINGDOM OF SAUDI ARABIA

S. No.	Station / City	DD*
1	TURAIF	1,800
2	ARAR	2,600
3	GURIAT	1,800
4	AL-JOUF	2,500
5	RAFHA	2,900
6	QAISUMAH	3,400
7	TABUK	2,300
8	HAFAR AL-BATIN	3,600
9	HAIL	2,600
10	WEJH	2,800
11	GASSIM	3,300
12	DHARHAN	3,500
13	AL-HASA	3,800
14	MADINAH	4,200
15	RIYADH	3,800
16	BISHA	3,500
17	KHAMIS MUSHAIT	1,200
18	JEDDAH-KFIA	3,900
19	TAIF	2,200
20	MAKKAH	4,900
21	YANBU	4,000
22	AL-BAHA	2,100
23	WADI-ALDAWASER	3,800
24	ABHA	1,000
25	NAJRAN	3,000
26	SHARORAH	4,000
27	GIZAN	4,600

* (Base 18°C) and DD values are rounded off to the nearest hundred.

CHAPTER 3
RESIDENTIAL BUILDING DESIGN BY SYSTEMS ANALYSIS AND DESIGN OF BUILDINGS UTILIZING RENEWABLE ENERGY SOURCES

SECTION 3.1
GENERAL

3.1.1 **Scope.** This chapter establishes design criteria in terms of total energy use by a residential building, including all of its systems.

SECTION 3.2
SYSTEMS ANALYSIS

3.2.1 **Analysis procedure.** Except as explicitly specified by this chapter, the standard design home shall be configured and simulated using identical methods and techniques as are used in the configuration and simulation of the proposed design home.

3.2.2 **Energy analysis.** Compliance with this chapter will require an analysis of the annual energy usage, hereinafter called an "annual energy analysis."

Exception: Chapters 4 and 5 establish criteria for different energy-consuming and enclosure elements of the building which, if followed, will eliminate the requirement for an annual energy analysis while meeting the intent of this requirement.

3.2.2.1 **Standard design.** A building designed in accordance with this chapter will be deemed as complying with this requirement if the calculated annual energy consumption is not greater than a similar building (defined as a "standard design") whose enclosure elements and energy-consuming systems are designed in accordance with Chapter 4. Specific building envelope elements of the standard design shall comply with Sections 3.2.2.1.1 through 3.2.2.1.4.

3.2.2.1.1 **Exterior walls.** The exterior wall assembly *U*-Factors for the standard design shall be selected by climate in accordance with Table 3.2.2.1.1.

3.2.2.1.2 **Fenestration *U*-factor.** The fenestration system *U*-Factor used in the standard design shall be selected by climate in accordance with Table 3.2.2.1.2.

3.2.2.1.3 **Window area.** The window area of the standard design, inclusive of the framed sash and glazing area, shall be equal to 18 percent of the conditioned floor area of the proposed design.

3.2.2.1.4 **Skylights.** Skylights and other non-vertical roof glazing elements shall not be included in the standard design, and ceiling *U*-factors used in the standard design shall not include such elements in their computation.

3.2.2.2 **Proposed design.** For a proposed alternative building design (defined as a "proposed design") to be considered similar to a "standard design," it shall utilize the same nonrenewable energy source(s) for the same functions and have equal conditioned floor area and the same ratio of thermal envelope area to floor area (i.e., the same geometry), exterior design conditions, occupancy, climate data, and usage operational schedule as the standard design. Where an energy end use (such as space heating or domestic water)is to be provided entirely from renewable energy sources in a proposed design, the standard design shall assume an equipment type using a nonrenewable energy source common to that region for that end use as approved by the code official.

3.2.2.2.1 **Orientation for groups of buildings.** The worst possible orientation of the proposed design, in terms of annual energy use, considering north, northeast, east,

southeast, south, southwest, west and northwest orientations, shall be used to represent group of otherwise identical designs.

TABLE 3.2.2.1.1
STANDARD DESIGN WALL ASSEMBLY *U*-FACTORS (U_W)

Degree Days[a]	**U_w (air to air)**[b] W/(m^2 · ºK)
≥ 7,230	0.216
5,000 – 7,229	0.261
3,600 - 4,999	0.295
2,500 - 3,600	0.329
1,950 – 2,499	0.363
1,400 - 1,950	0.432
< 1400	0.483

a. From Table 2.2.1.
b. Including framing effects.

TABLE 3.2.2.1.2
STANDARD DESIGN FENESTRATION SYSTEM *U*-FACTORS (U_g OR U_F)

Degree Days[a]	**U_g for Section 5.2.2.1.1 and U_f for Section 5.2.2.3.1 (air to air)**[b] W(m^2 · ºK)
≥ 7,230	1.42
5,000 - 7,229	1.48
3,610 – 4,999	1.59
2,500 - 3,600	1.70
1,950 – 2,499	2.33
1,400 - 1,950	2.50
400 - 1,399	2.67
< 400	4.20

a. From Table 2.2.1.
b. Entire assembly, including sash.

3.2.2.3 **Input values for residential buildings.** The input values in Sections 3.2.2.3.1 through 3.2.2.3.11 shall be used in calculating annual energy performance. The requirements of this section specifically indicate which variables shall remain constant between the standard design and proposed design calculations. The standard design shall be a base version of the design that directly complies with the provisions of this requirement. The proposed building shall be permitted to utilize a design methodology that is demonstrated, through calculations satisfactory to the code official, to have equal or lower annual energy use than the standard design.

3.2.2.3.1 **Glazing systems.** The input values in Sections 3.2.2.3.1.1 through 3.2.2.3.1.4, specific to glazing systems, shall be used in calculating annual energy performance.

3.2.2.3.1.1 **Orientation, standard design.** As a minimum, equal areas on north, east, south and west exposures shall be assumed.

3.2.2.3.1.2 **Exterior shading, standard design.** Glazing areas in the standard design shall not be provided with exterior shading such as roof overhangs. Energy performance impacts of added exterior shading for glazing areas which are accounted for in the proposed design for a specific building shall be permitted, provided that the code official approves the actual installation of such systems.

3.2.2.3.1.3 **Fenestration system solar heat gain coefficient, standard design.** The fenestration system solar heat gain coefficient (SHGC), inclusive of framed sash and glazing area, of the glazing systems in the standard design shall be 0.40 for DD < 1,950 and 0.68 for DD ≥ 1,950 during periods of mechanical heating and cooling operation. These fenestration system SHGC values shall be multiplied together with (added in series to)the interior shading values as specified in Section 3.2.2.3.1.4 to arrive at an overall solar heat gain coefficient for the installed glazing system. Where the SHGC characteristics of the proposed fenestration products are not known, the default SHGC values given in Table 1.2.5.2(3) shall be used for the proposed design.

3.2.2.3.1.4 **Interior shading, standard design and proposed design.** The same schedule of interior shading values, expressed as the fraction of the solar heat gain admitted by the fenestration system that is also admitted by the interior shading, shall be assumed for the standard and proposed designs. The values used for interior shading shall be 0.70 in summer and 0.90 in winter.

3.2.2.3.2 **Heat storage (thermal mass).** The following input values, specific to heat storage (thermal mass), shall be used in calculating annual energy performance:

Internal mass: 39 kg/m^2
Structural mass: 17 kg/m^2

3.2.2.3.3 **Building thermal envelope – surface areas and volume.** The input values in Sections 3.2.2.3.3.1 through 3.2.2.3.3.4, specific to building thermal envelope surface areas, shall be used in calculating annual energy performance.

3.2.2.3.3.1 **Floors, walls, ceiling.** The standard and proposed designs shall have equal areas.

3.2.2.3.3.2 **Foundation and floor type.** The foundation and floor type for both the standard and proposed designs shall be equal.

3.2.2.3.3.3 **Doors.** The opaque door area of the standard design shall equal that of the proposed design and shall have a *U*-factor of 1.14 W/$m^2 \cdot$ K.

3.2.2.3.3.4 **Building volume.** The volume of both the standard and proposed designs shall be equal.

3.2.2.3.4 **Heating and cooling controls.** Unless otherwise specified by local codes, heating and cooling thermostats shall comply with Table 3.2.2.3.4 for the standard and proposed designs. The input values specific to heating and cooling controls, shall be used in calculating annual energy performance.

TABLE 3.2.2.3.4
HEATING AND COOLING CONTROLS

Parameter	Standard Design Value	Proposed Design Value
Heating	20ºC	20ºC
Cooling	25.5ºC	25.5ºC
Setback/setup	2.8ºC	Maximum of 2.8ºC
Setback/setup duration	6 hours per day	Maximum of 6 hours per day
Number of setback/setup periods per unit[a]	1	Maximum of 1
Maximum number of zones per unit[a]	2	2
Number of thermostats per zone	1	1

[a] Units =Number of dwelling units in standard and proposed designs.

3.2.2.3.5 **Internal heat gains.** Equation 3-1 shall be used to determine the input values, specific to internal heat gains that shall be used in both the standard design and the proposed design in calculating annual energy performance:

$$I\text{-}Gain = 17{,}900 + (23.8 \cdot CFA) + (4140 \cdot BR) \qquad \textbf{(Equation 3-1)}$$

Where:
I-Gain = Internal gains in kWh/day per dwelling unit.
CFA = Conditioned floor area.
BR = Number of bedrooms.

3.2.2.3.6 **Domestic hot water (calculate, then constants).** The following input values, specific to domestic hot water, shall be used in calculating annual energy performance.

Temperature set point 49°C
Daily hot water consumption Gallons = (30 *a*) + (10 *b*)

Where:
a = Number of dwelling units in standard and proposed designs.
b = Number of bedrooms in each dwelling unit.

3.2.2.3.7 **Site weather data (constants).** The typical meteorological year (TMY2), or its "ersatz" equivalent, from the National Oceanic and Atmospheric Administration (NOAA), or an approved equivalent, for the closest available location shall be used.

3.2.2.3.8 **Forced-air distribution system loss factors (DLF).** The heating and cooling system efficiency shall be proportionately adjusted for those portions of the ductwork located outside or inside the conditioned space using the values shown below:

System Operating Mode	**Duct Location**	
	Outside	**Inside**
Heating	0.80	1.00
Cooling	0.80	1.00

Note: Ducts located in a space that contains a positive heating supply or cooling supply, or both, shall be considered inside the building envelope.

Impacts from improved distribution loss factors (DLF) shall be accounted for in the proposed design only if the entire air distribution system is specified on the construction documents to be substantially leak free, and is tested after installation

to ensure that the installation is substantially leak free. "Substantially leak free" shall be defined as the condition under which the entire air distribution system (including the air handler cabinet) is capable of maintaining a 25 Pa internal pressure at 5 percent or less of the air handler's rated air-flow when the return grilles and supply registers are sealed off. This test shall be conducted using methods and procedures as specified in (Section 3 of the SMACNA *HVAC Air Duct Leakage Test Manual*), or by using other, similar pressurization test methods and as approved by the code official.

Where test results show that the entire distribution system is substantially leak free, then seasonal DLFs shall be calculated separately for heating and cooling modes using engineering methods capable of considering the net seasonal cooling energy heat gain impacts and the net seasonal heating energy heat loss impacts that result from the portion of the thermal air distribution system that is located outside the conditioned space. Once these heating and cooling season "distribution system energy impacts" are known, then heating and cooling mode DLFs for the proposed design shall be calculated using Equations 3-2 and 3-3:

Total Seasonal Energy = Seasonal Building Energy + Distribution System Energy Impacts **(Equation 3-2)**

DLF = Seasonal Building Energy/Total Seasonal Energy **(Equation 3-3)**

Once the DLFs for the heating and cooling seasons are known, the total "adjusted system efficiency" is calculated using Equation 3-4:

Adjusted System Efficiency = (Equipment Efficiency DLF Percent of Duct Outside) + (Equipment Efficiency DLF Percent of Duct Inside)

(Equation 3-4)

Equation 3-4 shall be used to develop adjusted system efficiency for each heating and cooling system included in the standard design. Where a single system provides both heating and cooling, efficiencies shall be calculated separately for heating and cooling modes.

3.2.2.3.9 **Air infiltration.** Annual average air changes per hour (ACH) for the standard design shall be determined using the following equation:

ACH = Normalized Leakage × Weather Factor **(Equation 3-5)**

Where:
Normalized leakage = 0.57
and
Weather factor is determined in accordance with the weather factors (*W*) given by (ASHRAE 136), as taken from the weather station nearest the building site.

Where the proposed design takes credit for reduced ACH levels, documentation of measures providing such reductions, and results of a post-construction blower-door test shall be provided to the code official using (ASTM E 779). No energy credit shall be granted for ACH levels below 0.35.

3.2.2.3.10 **Foundation walls.** When performing annual energy analyses for buildings with insulated basement or crawl space walls, the design *U*-factors taken from Table 4.2.2 for these walls of the standard building shall be permitted to be decreased by accounting for the *R*-values of the adjacent soil, provided that the foundation wall *U*-factor of the proposed building also accounts for the *R*-value of the adjacent soil.

3.2.2.3.11 **Heating and cooling system equipment efficiency, standard design.** The efficiency of the heating and cooling equipment shall meet, but not exceed the minimum efficiency requirement in Section 4.3.2. Where the proposed design

utilizes an electric resistance space heating system as the primary heating source, the standard design shall utilize an air-cooled heat pump that meets but does not exceed the minimum efficiency requirements in Section 4.3.2.

3.2.3 **Design.** The standard design, conforming to the criteria of Chapter 4 and the proposed design shall be designed on a common basis as specified in Sections 3.2.3.1 through 3.2.3.3.

3.2.3.1 **Units of energy.** The comparison shall be expressed as W/m^2 of gross floor area per year at the building site.

3.2.3.2 **Equivalent energy units.** If the proposed design results in an increase in consumption of one energy source and a decrease in another energy source, even though similar sources are used for similar purposes, the difference in each energy source shall be converted to equivalent energy units for purposes of comparing the total energy used.

3.2.3.3 **Site energy.** The different energy sources shall be compared on the basis of energy use at the site.

3.2.4 **Analysis procedure.** The analysis of the annual energy usage of the standard and the proposed alternative building and system designs shall meet the criteria specified in Sections 3.2.4.1 and 3.2.4.2.

3.2.4.1 **Load calculations.** The building heating and cooling load calculation procedures used for annual energy consumption analysis shall be detailed to permit the evaluation of effect of factors specified in Section 3.2.4.

3.2.4.2 **Simulation details.** The calculation procedure used to simulate the operation of the building and its service systems through a full-year operating period shall be detailed to permit the evaluation of the effect of system design, climatic factors, operational characteristics, and mechanical equipment on annual energy usage. Manufacturer's data or comparable field test data shall be used when available in the simulation of systems and equipment. The calculation procedure shall be based on 8,760 hours of operation of the building and its service systems and shall utilize the design methods specified in the ASHRAE *Fundamentals Handbook*.

3.2.5 **Calculation procedure.** The calculation procedure shall include the items specified in Sections 3.2.5.1 through 3.2.5.7.

3.2.5.1 **Design requirements.** Environmental requirements as required in Chapter 3.

3.2.5.2 **Climatic data.** Coincident hourly data for temperatures, solar radiation, wind and humidity of typical days in the year representing seasonal variation.

3.2.5.3 **Building data.** Orientation, size, shape, framing, mass, air, moisture and heat transfer characteristics.

3.2.5.4 **Operational characteristics.** Temperature, humidity, ventilation, illumination and control mode for occupied and unoccupied hours.

3.2.5.5 **Mechanical equipment.** Design capacity and part-load profile.

3.2.5.6 **Building loads.** Internal heat generation, lighting, equipment and number of people during occupied and unoccupied periods.

3.2.5.7 **Use of approved calculation tool.** The same calculation tool shall be used to estimate the annual energy usage for space heating and cooling of the standard design and the proposed design. The calculation tool shall be approved by the code official.

3.2.6 **Documentation.** Proposed alternative designs, submitted as requests for exception to the standard design criteria, shall be accompanied by an energy analysis comparison report. The report shall provide technical detail on the standard and

proposed designs and on the data used in and resulting from the comparative analysis to verify that both the analysis and the designs meet the criteria of Chapter 3.

Exception: Proposed alternative designs for residential buildings having a conditioned floor area of 460 m^2 or less are exempted from the hourly analysis described in Sections 3.2.4 and 3.2.5 However, a comparison of energy consumption using correlation methods based on full-year hourly simulation analysis or other engineering methods that are capable of estimating the annual heating, cooling and hot water use between the proposed alternative design and the standard design shall be provided.

CHAPTER 4
RESIDENTIAL BUILDING DESIGN BY COMPONENT PERFORMANCE APPROACH

SECTION 4.1
GENERAL

4.1.1 **Scope.** Residential buildings or portions thereof that enclose conditioned space shall be constructed to meet the requirements of this chapter.

SECTION 4.2
BUILDING ENVELOPE REQUIREMENTS

4.2.1 **General requirements.** The building envelope shall comply with the applicable provisions of Sections 4.2.1.1 through 4.2.1.5 regardless of the means of demonstrating envelope compliance as set forth in Section 4.2.2.

4.2.1.1 **Moisture control.** The design shall not create conditions of accelerated deterioration from moisture condensation. Frame walls, floors and ceilings not ventilated to allow moisture to escape shall be provided with an approved vapor retarder having a permeance rating of 1 perm (5.7×10^{-11} kg/Pa · s · m^2) or less, when tested in accordance with the desiccant method using Procedure A of (ASTM E 96). The vapor retarder shall be installed on the cool-in-summer (warm-in-winter) side of the thermal insulation.

Exceptions:

1. Where the region in which the building is being constructed is considered a hot and humid climate area.
2. In construction where moisture or its freezing will not damage the materials.
3. Where other approved means to avoid condensation in unventilated framed wall, floor, roof and ceiling cavities are provided.

4.2.1.2 **Masonry veneer.** When insulation is placed on the exterior of a foundation supporting a masonry veneer exterior, the horizontal foundation surface supporting the veneer is not required to be insulated to satisfy any foundation insulation requirement.

4.2.1.3 **Recessed lighting fixtures.** When installed in the building envelope, recessed lighting fixtures shall meet one of the following requirements:

1. Type IC rated, manufactured with no penetrations between the inside of the recessed fixture and ceiling cavity and sealed or gasketed to prevent air leakage into the unconditioned space.
2. Type IC or non-IC rated, installed inside a sealed box constructed from a minimum 12-mm-thick gypsum wallboard or constructed from a preformed polymeric vapor barrier, or other air-tight assembly manufactured for this purpose, while maintaining required clearances of not less than 12 mm from combustible material and not less than 75 mm from insulation material.
3. Type IC rated, in accordance with (ASTM E 283) admitting no more than 1 L/s of air movement from the conditioned space to the ceiling cavity. The lighting fixture shall be tested at 75 Pa pressure difference and shall be labeled.

4.2.1.4 **Air leakage.** Provisions for air leakage shall be in accordance with Sections 4.2.1.4.1 and 4.2.1.4.2.

4.2.1.4.1 **Window and door assemblies.** Window and door assemblies installed in the building envelope shall comply with the maximum allowable air leakage rates in Table 4.2.1.4.1.

Exception: Site-constructed windows and doors sealed in accordance with Section 4.2.1.4.2.

TABLE 4.2.1.4.1
ALLOWABLE AIR LEAKAGE RATES [a, b]

Windows, L/s per m^2 of window area	Doors, L/s per m^2 of door area	
	Sliding	Swinging
1.5 [b,d]	1.5 [d]	2.5 [c,d]

a. When tested in accordance with (ASTM E 283).
b. See (AAMA/WDMA 101/I.S.2).
c. Requirement based on assembly area.
d. See (NFRC 300).

4.2.1.4.2 **Caulking and sealants.** Exterior joints, seams or penetrations in the building envelope, that are sources of air leakage, shall be sealed with durable caulking materials, closed with gasketing systems, taped or covered with moisture vapor-permeable house wrap. Sealing materials spanning joints between dissimilar construction materials shall allow for differential expansion and contraction of the construction materials.

This includes sealing around tubs and showers, at the attic and crawl space panels, at recessed lights and around all plumbing and electrical penetrations. These are openings located in the building envelope between conditioned space and unconditioned space or between the conditioned space and the outside.

4.2.1.5 **Fenestration solar heat gain coefficient.** In locations with degree days (DD) less than 1,950, the combined solar heat gain coefficient (the area-weighted average) of all glazed fenestration products (including the effects of any permanent exterior solar shading devices) in the building shall not exceed 0.4.

4.2.2 **Heating and cooling criteria.** The building envelope shall meet the provisions of Table 4.2.2 Compliance shall be demonstrated in accordance with Section 4.2.2.1, 4.2.2.2, 4.2.2.3, 4.2.2.4 or 4.2.2.5, as applicable.

Energy measure trade offs utilizing equipment exceeding the requirements of Section 4.3, 4.4 or 4.5 shall only use the compliance methods described in Chapter 3.

TABLE 4.2.2
HEATING AND COOLING CRITERIA [a]

Element	Mode	Type A-1 Residential Buildings U_o	Type -2 Residential Buildings U_o
Walls	Heating or cooling	—	—
Roof/ceiling	Heating or cooling	—	—
Floors over unheated spaces	Heating or cooling	—	—
Heated slab on grade [b,f]	Heating	*R*-value =	*R*-value =
Unheated slab on grade [c,d,f]	Heating	*R*-value =	*R*-value =
Basement wall[e,f]	Heating or cooling	*U*-factor =	*U*-factor =
Crawl space wall[e,f]	Heating or cooling	*U*-factor =	*U*-factor =

a. Values shall be determined by using the graphs [Figures 4.2.2(1), 4.2.2(2), 4.2.2(3), 4.2.2(4), 4.2.2(5) and 4.2.2(6)] using DD as specified in Section 3.2.
b. There are no insulation requirements for slabs in locations having less than 275 DD.
c. There are no insulation requirements for slabs in locations having less than 1,400 DD.
d. Slab edge insulation is not required for slabs in areas of very heavy termite infestation probability in accordance with Section 4.2.2.1.4, and as shown in Figure 4.2.2 (7).
e. Basement and crawl space wall *U*-factors shall be based on the wall components and surface air films. Adjacent soil shall not be considered in the determination of the *U*-factor.
f. Typical foundation insulation techniques can be found in the *Building Foundation Design Handbook*.

4.2.2.1 **Compliance by performance on an individual component basis.** Each component of the building envelope shall meet the provisions of Table 4.2.2 as provided in Sections 4.2.2.1.1 through 4.2.2.1.6.

4.2.2.1.1 **Walls.** The combined thermal transmittance value (U_o) of the gross area of exterior walls shall not exceed the value given in Table 4.2.2. Equation 4-1 shall be used to determine acceptable combinations to meet these Requirements:

$$U_o = \frac{(U_w \times A_w) + (U_g \times A_g) + (U_d \times A_d)}{A_o} \qquad \textbf{(Equation 4-1)}$$

Where:

U_o = The average thermal transmittance of the gross area of the exterior walls.

A_o = The gross area of exterior walls.

U_w = The combined thermal transmittance of the various paths of heat transfer through the opaque exterior wall area.

A_w = Area of exterior walls that are opaque.

U_g = The combined thermal transmittance of all glazing within the gross area of exterior walls.

A_g = The area of all glazing within the gross area of exterior walls.

U_d = The combined thermal transmittance of all opaque doors within the gross area of exterior walls.

A_d = The area of all opaque doors within the gross area of exterior walls.

Notes: (1) When more than one type of wall, window or door is used, the *U* and *A* terms for those items shall be expanded into sub-elements as:

$$(U_{w1}\, A_{w1}) + (U_{w2}\, A_{w2}) + (U_{w3}\, A_{w3}) + \ldots \text{ (etc.)} \qquad \textbf{(Equation 4-2)}$$

(2) Access doors or hatches in a wall assembly shall be included as a sub-element of the wall assembly.

4.2.2.1.1.1 **Steel stud framed walls.** When the walls contain steel stud framing, the value of U_w used in Equation 4-1 shall be recalculated using a series path procedure to correct for parallel path thermal bridging. The U_w for purposes of Equation 4-1 of steel stud walls shall be determined as follows:

$$U_w = \frac{1}{[R_s + (R_{ins} \times F_c)]} \qquad \textbf{(Equation 4-3)}$$

Where:

R_s = The total thermal resistance of the elements comprising the wall assembly along the path of heat transfer, excluding the cavity insulation and the steel stud.

R_{ins} = The *R*-value of the cavity insulation.

F_c = The correction factor listed in Table 4.2.2.1.1.1.

Exception: Overall system tested U_w values for steel stud framed walls from approved laboratories, when such data are acceptable to the code official.

TABLE 4.2.2.1.1.1
F_C VALUES FOR WALL SECTIONS WITH STEEL STUDS PARALLEL PATH CORRECTION FACTORS

Nominal Stud Size (mm)[a]	Spacing of Framing (m)	Cavity Insulation *R*-Value	Correction Factor
50 × 100	0.4 o.c.	R-1.9 R-2.3 R-2.6	0.50 0.46 0.43
50 × 100	0.6 o.c.	R-1.9 R-2.3 R-2.6	0.60 0.55 0.52
50 × 150	0.4 o.c.	R-3.3 R-3.7	0.37 0.35
50 × 150	0.6 o.c.	R-3.3 R-3.7	0.45 0.43
50 × 200	0.4 o.c.	R-4.4	0.31
50 × 200	0.6 o.c.	R-4.4	0.38

a. Applies to steel studs up to a maximum thickness of 0.00164 m (16 gage).

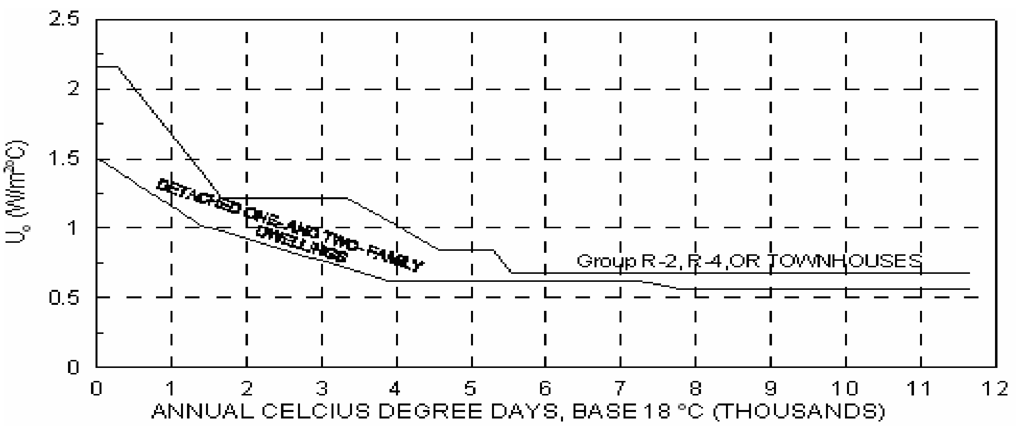


FIGURE 4.2.2 (1)

U_o-FACTORS-WALLS: RESIDENTIAL BUILDINGS

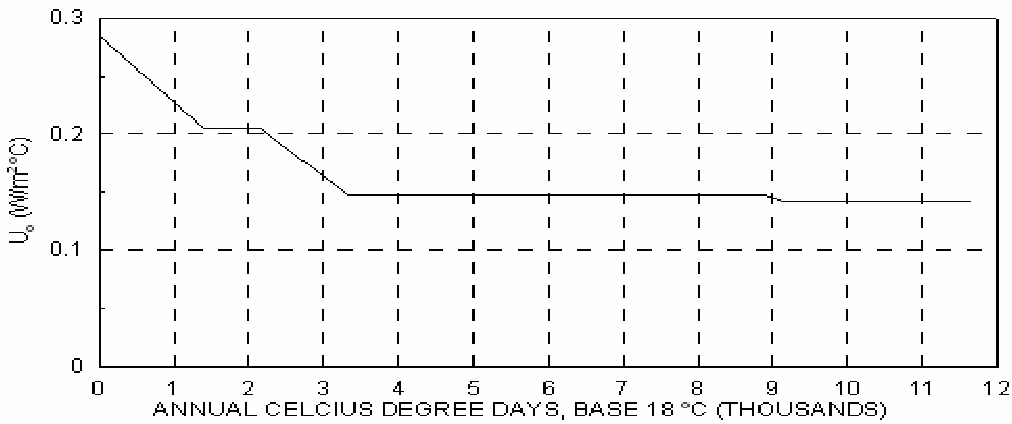


FIGURE 4.2.2 (2)
U_o-FACTORS-ROOF/CEILINGS

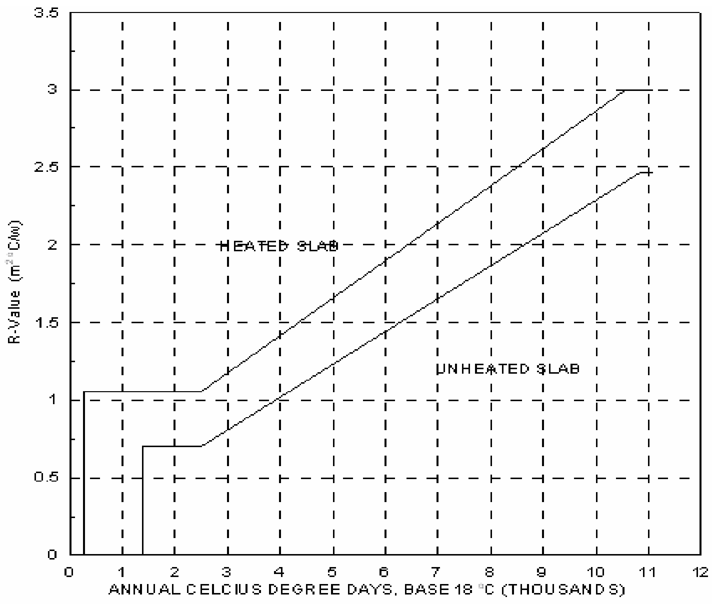


FIGURE 4.2.2 (3)

R-VALUES-SLAB ON GRADE

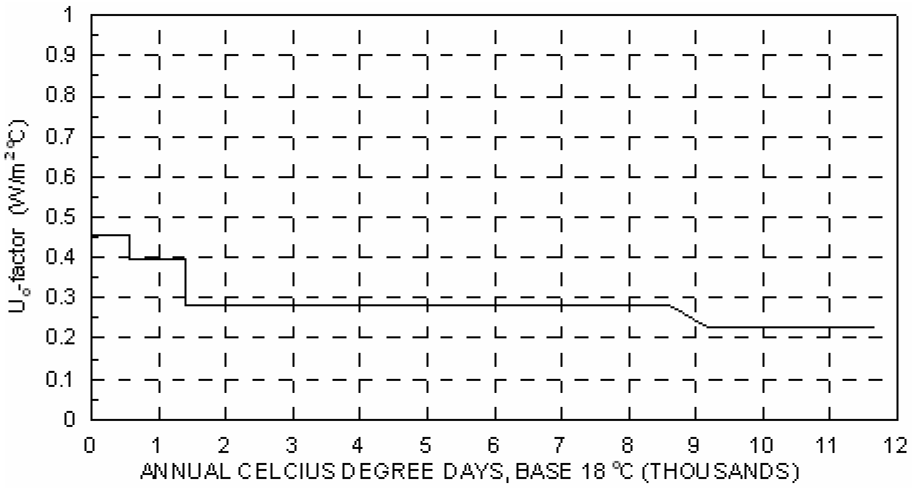


FIGURE 4.2.2 (4)

U_o-FACTORS-FLOR OVER UNHEATED SPACES

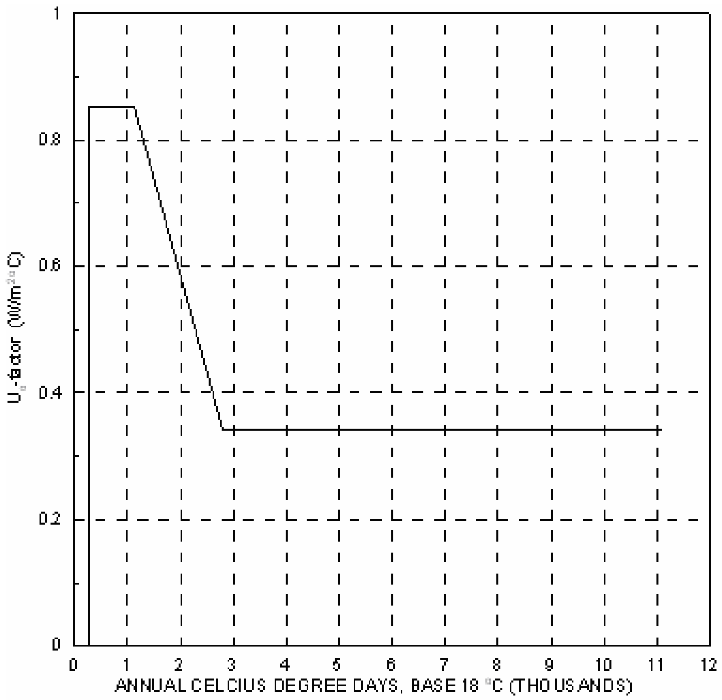


FIGURE 4.2.2 (5)

U-FACTORS-CRAWL SPACE WALLS

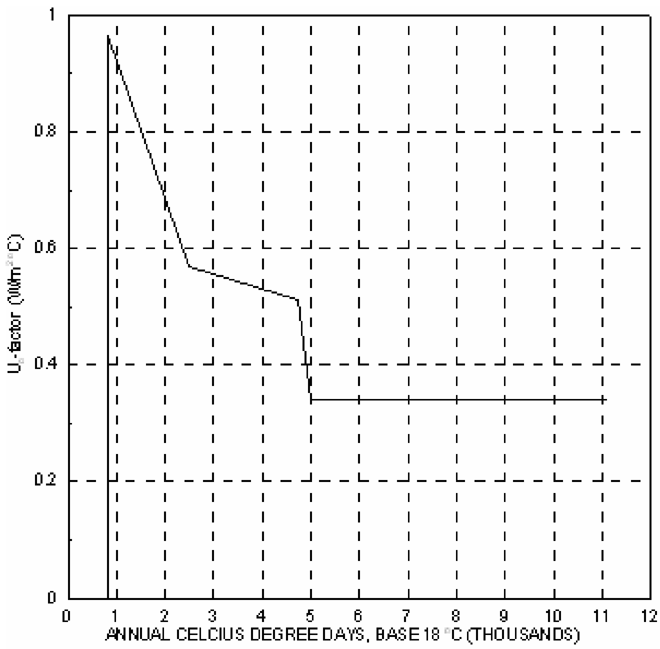


FIGURE 4.2.2 (6)

U-FACTORS-BASEMENT WALLS

4.2.2.1.1.2 **Mass walls.** When thermal mass credit is desired for an exterior wall having a heat capacity greater than or equal to 1 kJ/(m^2 · K), the U_w for such a wall shall be less than or equal to the applicable value in Table 4.2.2.1.1.2(1), 4.2.2.1.1.2(2) or 4.2.2.1.1.2(3) based on the U_w required for an exterior wall having a heat capacity less than 1 kJ/(m^2 · K) as determined by Section 4.2.2.1.1, Equation 4-1 and Figure 4.2.2(1).

Note: Masonry or concrete walls having a mass greater than or equal to 145 kg/m^2 of exterior wall area and solid wood walls having a mass greater than or equal to 100 kg/m^2 of exterior wall area have heat capacities equal to or exceeding 1 kJ/(m$^2 \cdot$ K) of exterior wall area.

The heat capacity of the wall shall be determined using Equation 4-4 as follows:

$$HC = w \times c \qquad \textbf{(Equation 4-4)}$$

Where:

HC = Heat capacity of the exterior wall, [kJ/(m$^2 \cdot$ K) of exterior wall area.

w = Mass of the exterior wall, kg/m^2 of exterior wall area is the density of the exterior wall material, kg/m^3 multiplied by the thickness of the exterior wall, m.

c = Specific heat of the exterior wall material, kJ/(kg · K) of exterior wall area as determined from Chapter 24 of the ASHRAE *Fundamentals Handbook*.

4.2.2.1.2 **Roof/ceiling.** The combined thermal transmittance value (U_o) of the gross area of the roof or ceiling assembly shall not exceed the value given in Table 4.2.2. Equation 4-5 shall be used to determine acceptable combinations to meet these Requirements.

$$U_o = \frac{(U_R \times A_R) + (U_S \times A_S)}{A_o} \qquad \textbf{(Equation 4-5)}$$

Where:

U_o = The average thermal transmittance of the gross roof/ceiling area, W/(m$^2 \cdot$ K).

A_o = The gross area of the roof/ceiling assembly, m^2.

U_R = The combined thermal transmittance of the various paths of heat transfer through the opaque roof/ceiling area, W/(m$^2 \cdot$ K).

A_R = Opaque roof/ceiling assembly area, m^2.

U_s = The combined thermal transmittance of the area of all skylight elements in the roof/ceiling assembly (See Section 4.2.2.1.2.1), W/(m$^2 \cdot$ K).

A_s = The area (including frame) of all skylights in the roof/ceiling assembly, m^2 (see Section 4.2.2.1.2.1).

Notes:

(1) When more than one type of roof/ceiling and/or skylight is used, the *U* and *A* terms for those items shall be expanded into their sub elements as in Equation 4-6:

$$(U_{R1} \times A_{R1}) + (U_{R2} \times A_{R2}) + ...etc. \qquad \textbf{(Equation 4-6)}$$

(2) Access doors or hatches in a roof/ceiling assembly shall be included as a sub element of the roof/ceiling assembly.

(3) When the roof/ceiling assembly contains cold-formed steel truss framing, the U_R value to be used in Equation 4-5 shall be determined by Equation 4-7, 4-8, or 4-9. These equations apply to cold-formed steel truss roof framing spaced at 60 cm on-center and where the penetrations of the truss members through the cavity insulation do not exceed three penetrations for each 120 cm length of the truss.

For constructions without foam between the drywall and bottom chord of the steel truss use Equation 4-7: 1

$$U_R = \frac{5.678}{(0.152 \times R_{ins}) + 0.330} \quad \text{W/m}^2 \cdot {}^\circ\text{C} \qquad \textbf{(Equation 4-7)}$$

Where:

R_{ins} = The *R*-value of the cavity insulation, m$^2 \cdot$ K/kW.

TABLE 4.2.2.1.1.2(1)
REQUIRED U_W FOR WALL WITH A HEAT CAPACITY EQUAL TO OR EXCEEDING 1 kJ/(m^2 · K) WITH INSULATION PLACED ON THE EXTERIOR OF THE WALL MASS

Degree Days	U_w Required for Walls with a Heat Capacity Less than 1 kJ/(m^2 · K) as Determined by Using Equation 4-1 and Figure 4.2.2 (1)										
	1.36	**1.25**	**1.14**	**1.02**	**0.91**	**0.80**	**0.68**	**0.57**	**0.45**	**0.34**	**0.23**
0-1109	1.87	1.76	1.59	1.48	1.31	1.19	1.02	0.91	0.74	0.63	0.45
1110-2219	1.82	1.70	1.53	1.42	1.25	1.14	0.97	0.85	0.74	0.57	0.45
2220-3049	1.70	1.59	1.42	1.31	1.19	1.02	0.91	0.80	0.63	0.51	0.40
3050-3599	1.59	1.48	1.31	1.19	1.08	0.97	0.85	0.68	0.57	0.45	0.34
3600-4439	1.48	1.36	1.25	1.08	0.97	0.85	0.74	0.63	0.51	0.40	0.28
> 4440	1.36	1.25	1.14	1.02	0.91	0.80	0.68	0.57	0.45	0.34	0.23

TABLE 4.2.2.1.1.2(2)
REQUIRED U_W FOR WALL WITH A HEAT CAPACITY EQUAL TO OR EXCEEDING 1 kJ/(m^2 · K) WITH INSULATION PLACED ON THE INTERIOR OF THE WALL MASS

Degree Days	U_w Required for Walls with a Heat Capacity Less than 1 kJ/(m^2 · K) as Determined by Using Equation 4-1 and Figure 4.2.2 (1)										
	1.36	**1.25**	**1.14**	**1.02**	**0.91**	**0.80**	**0.68**	**0.57**	**0.45**	**0.34**	**0.23**
0-1109	1.65	1.53	1.42	1.25	1.14	0.97	0.85	0.68	0.51	0.40	0.23
1110-2219	1.59	1.48	1.36	1.19	1.08	0.91	0.80	0.68	0.51	0.40	0.23
2220-3049	1.53	1.42	1.31	1.19	1.08	0.91	0.80	0.63	0.51	0.40	0.23
3050-3599	1.48	1.36	1.25	1.14	0.97	0.85	0.74	0.63	0.51	0.34	0.23
3600-4439	1.42	1.31	1.19	1.08	0.97	0.80	0.68	0.57	0.45	0.34	0.23
> 4440	1.36	1.25	1.14	1.02	0.91	0.80	0.68	0.57	0.45	0.34	0.23

TABLE 4.2.2.1.1.2(3)
REQUIRED U_W FOR WALL WITH A HEAT CAPACITY EQUAL TO OR EXCEEDING 1 kJ/(m^2 · K) WITH INTEGRAL INSULATION (INSULATION AND MASS MIXED, SUCH AS A LOG WALL)

Degree Days	U_w Required for Walls with a Heat Capacity Less than 1 kJ/(m^2 · K) as Determined by Using Equation 4-1 and Figure 4.2.2(1)										
	1.36	**1.25**	**1.14**	**1.02**	**0.91**	**0.80**	**0.68**	**0.57**	**0.45**	**0.34**	**0.23**
0-1109	1.87	1.76	1.59	1.42	1.31	1.14	0.97	0.85	0.68	0.51	0.40
1110-2219	1.82	1.70	1.53	1.36	1.25	1.08	0.97	0.80	0.63	0.51	0.34
2220-3049	1.70	1.59	1.48	1.31	1.19	1.02	0.91	0.74	0.63	0.45	0.34
3050-3599	1.59	1.48	1.36	1.19	1.08	0.97	0.80	0.68	0.57	0.45	0.28
3600-4439	1.48	1.36	1.25	1.14	1.02	0.85	0.74	0.63	0.51	0.40	0.28
> 4440	1.36	1.25	1.14	1.02	0.91	0.80	0.68	0.57	0.45	0.34	0.23

For constructions with R-0.5 foam between the drywall and bottom chord of the steel truss use Equation 4-8:

$$U_R = \frac{5.678}{(0.15 \times R_{ins}) + 4.994} \quad \text{W/m}^2 \cdot {}^{o}\text{C} \qquad \textbf{(Equation 4-8)}$$

R_{ins} = The R-value of the cavity insulation, m^2 · K/kW.

For constructions with R-0.9 foam between the drywall and bottom chord of the steel truss use Equation 4-9:

$$U_R = \frac{5.678}{(0.15 \times R_{ins}) + 7.082} \quad \text{W/m}^2 \cdot {}^{o}\text{C} \qquad \textbf{(Equation 4-9)}$$

R_{ins} = The R-value of the cavity insulation, m^2 · K/kW.

Exception: Overall system tested U_R values for roof/ceiling assemblies from approved laboratories, when such data are acceptable to the code official.

(4) When the roof/ceiling assembly contains conventional C-shaped cold-formed joist/rafter steel framing, the U_R value to be used in equation 4-5 shall be determined Equation 4-10 as follows:

$$U_R = \frac{1}{R_s + \left(R_{ins} \times F_{cor}\right)} \quad \textbf{(Equation 4-10)}$$

Where:

R_S = The total thermal resistance of the elements of roof/ceiling construction, in a series along the path of heat transfer, excluding the cavity insulation and the steel framing, $m^2 \cdot {}^oC/W$.

R_{ins} = The *R*-value of the cavity insulation, $m^2 \cdot {}^oC/W$.

F_{cor} = The correction factor listed in Table 4.2.2.1.2, dimensionless.

Exception: Overall system tested U_R values for roof/ceiling assemblies from approved laboratories, when such data are acceptable to the code official.

TABLE 4.2.2.1.2
CORRECTION FACTORS (f_{cpr}) FOR ROOF/CEILING ASSEMBLIES

Member Size[a] (mm)	Spacing of Framing Members[b] (m)	Cavity Insulation *R*-Value			
		R-3.3	R-5.3	R-5.3	R-6.7
50 × 100	0.4 o.c.	0.90	0.94	0.95	0.96
50 × 150		0.70	0.81	0.85	0.88
50 × 200		0.35	0.65	0.72	0.78
50 × 250		0.35	0.27	0.62	0.70
50 × 300		0.35	0.27	0.51	0.62
50 × 100	0.6 o.c.	0.95	0.96	0.97	0.97
50 × 150		0.78	0.86	0.88	0.91
50 × 200		0.44	0.72	0.78	0.83
50 × 250		0.44	0.35	0.69	0.76
50 × 300		0.44	0.35	0.61	0.69

a. Applies to steel framing members up to a maximum thickness of 1.65 mm (16 gage).
b. Linear interpolation is permitted for determining correction factors which are between those given in the table.

4.2.2.1.2.1 Skylights. Skylight shafts, 30 cm in depth and greater, shall be insulated to no less than R-2.3 in climates 0 - 2,220 DD and R-3.3 in climates greater than 2,220 DD. The skylight shaft thermal performance shall not be included in the roof thermal transmission coefficient calculation.

4.2.2.1.3 Floors over unheated spaces. The combined thermal transmittance factor (U_o) of the gross area of floors over unheated spaces shall not exceed the value given in Table 4.2.2. For floors over outdoor air (i.e., overhangs), U_o-factors shall not exceed the value for roofs given in Table 4.2.2. Equation 4-11 shall be used to determine acceptable combinations to meet these Requirements.

$$U_o = \frac{\left(U_{f1} \times A_{f1}\right) + \left(U_{f2} \times A_{f2}\right) + K + \left(U_{fn} \times A_{fn}\right)}{A_o} \quad \textbf{(Equation 4-11)}$$

Where:

U_o = The average thermal transmittance of the gross floor area, $W/(m^2 \cdot K)$.

A_o = The gross area of the different floor assemblies, m^2.

U_{fn} = The combined thermal transmittance of the various paths of heat transfer through the *n*th floor assembly, W/(m^2 · K).
A_{fn} = The area associated with the *n*th floor assembly, m^2.

Note: Access doors or hatches in a floor assembly shall be included as a sub-element of the floor assembly.

Exceptions: When the floor assembly contains C-shaped, cold-formed steel framing, the value of U_{fn} used in Equation 4-11 shall be recalculated using a series of path procedure to correct for parallel path thermal bridging. The U_{fn} for purposes of Equation 4-11 for C-shaped, cold-formed steel-framing construction shall be determined using Equation 4-12 as follows:

$$U_{fn} = \frac{1}{R_{fn} + \left(R_{ins} \times F_{cor}\right)} \qquad \textbf{(Equation 4-12)}$$

Where:

R_{fn} = The total thermal resistance of the elements of floor construction, in series along the path of heat transfer, excluding the cavity insulation and the steel joist, m^2 · ^{o}C/W.
R_{ins} = The *R*-value of the cavity insulation, m^2 · ^{o}C/W.
F_{cor} = The correction factor listed in Table 4.2.2.1.3, dimensionless.

Exception: Overall system tested U_{fn} values for steel-framed floors from approved laboratories, when such data are acceptable to the code official.

4.2.2.1.4 **Slab-on-grade floors.** The thermal resistance of the insulation around the perimeter of the floor shall not be less than the value given in Table 4.2.2. Where insulation is not required in accordance with foot noted to Table 4.2.2, building envelope compliance shall be demonstrated by using Section 4.2.2.2 or Chapter 3 with the actual slab insulation *R*-value in Table 4.2.2; or using Section 4.2.2.4.

Insulation shall be of an approved type, and placed on the outside of the foundation or on the inside of a foundation wall. In climates below 3,325 annual Celsius DD, the insulation shall extend downward from the elevation of the top of the slab for a minimum distance of 60 cm or downward to at least the bottom of the slab and then horizontally to the interior or exterior for a minimum total distance of 60 cm. In all climates equal to or greater than 3,325 DD, the insulation shall extend downward from the elevation of the top of the slab for a minimum of 120 cm or downward to at least the bottom of the slab and then horizontally to the interior or exterior for a minimum total distance of 120 cm. In all climates, horizontal insulation extending outside of the foundation shall be covered by pavement or by soil a minimum of 25 cm thick. The top edge of the insulation installed between the exterior wall and the edge of the interior slab shall be permitted to be cut at a 45-degree (0.8 rad) angle away from the exterior wall.

4.2.2.1.5 **Crawl space walls.** If the floor above a crawl space does not meet the requirements of Section 4.2.2.1.3 and the crawl space does not have ventilation openings that communicate directly with the outside air, then the exterior walls of the crawl space shall have a thermal transmittance value not exceeding the value given in Table 4.2.2. Where the inside ground surface is 30 cm or greater below the outside finish ground level, insulation shall extend from the top of the wall to at least the inside ground surface. Where the inside ground surface is less than 300 mm below the outside finish ground level, insulation shall extend from the top of the crawl space wall to the top of the footing.

TABLE 4.2.2.1.3
CORRECTION FACTORS (F_{cor}) FOR STEEL FLOOR ASSEMBLIES

Member Size[a] (mm)	Spacing of Framing Members[b] (m)	Cavity Insulation *R*-Value		
		R-3.3	R-5.3	R-6.7
50 × 150	0.4 o.c.	0.70	Not Applicable	Not applicable
50 × 200		0.35	Not Applicable	Not applicable
50 × 250		0.35	0.27	Not applicable
50 × 300		0.35	0.27	0.24
50 × 150	0.6 o.c.	0.78	Not applicable	Not applicable
50 × 200		0.44	Not applicable	Not applicable
50 × 250		0.44	0.35	Not applicable
50 × 300		0.44	0.35	0.32

a. Applies to steel framing members up to a maximum thickness of 1.65 mm (16 gage).
b. Linear interpolation is permitted for determining correction factors which are between those given in the table.

4.2.2.1.6 Basement walls. The exterior walls of conditioned basements shall have a transmittance value not exceeding the value given in Table 4.2.2 from the top of the basement wall to a depth of 3 m below the outside finish ground level, or to the level of the basement floor, whichever is less.

4.2.2.2 Compliance by total building envelope performance. The building envelope design of a proposed building shall be permitted to deviate from the U_o-factors, *U*-factors, or *R*-values specified in Table 4.2.2, provided the total thermal transmission heat gain or loss for the proposed building envelope does not exceed the total heat gain or loss resulting from the proposed building's conformance to the values specified in Table 4.2.2. For basement and crawl space walls that are part of the building envelope, the *U*-factor of the proposed foundation shall be adjusted by the *R*-value of the adjacent soil where the corresponding *U*-factor in Table 4.2.2 is similarly adjusted. Heat gain or loss calculations for slab edge and basement or crawl space wall foundations shall be determined using methods consistent with the ASHRAE *Fundamentals Handbook*.

4.2.2.3 Compliance by acceptable practice on an individual component basis. Each component of the building envelope shall meet the provisions of Table 4.2.2 as provided in Sections 4.2.2.3.1 through 4.2.2.3.6. The various walls, roof and floor assemblies described in Section 4.2.2.3 are typical and are not intended to be all inclusive. Other assemblies shall be permitted, provided documentation is submitted indicating the thermal transmittance value of the opaque section. Documentation shall be in accordance with accepted engineering practice.

4.2.2.3.1 Walls. The U_o of the exterior wall shall be determined in accordance with Equation 4-13.

$$U_o = \frac{(U_f \times A_f) + U_w \times (100 - A_f)}{100} \qquad \textbf{(Equation 4-13)}$$

Where:

U_o = The overall thermal transmittance of the gross exterior wall area.

U_f = The average thermal transmittance of the glazing area.

$$A_f = \frac{Glazing\ Area}{Gross\ Exterior\ Wall\ Area \times 100} \qquad \textbf{(Equation 4-14)}$$

U_w = The average thermal transmittance of the opaque exterior wall area.

The *U*-factor for the opaque portion of the exterior wall (U_w) shall meet the provisions of Table 4.2.2 as determined by Equation 4-13. The glazing *U*-factor (U_f) and the percentage of glazing area (A_f) shall consist of all glazed surfaces in the building envelope measured using the rough opening and including the sash, curbing and other framing elements that enclose conditioned spaces. The value of U_f shall be determined in accordance with Section 1.2.5.2. Opaque doors in the building envelope shall have a maximum *U*-factor of 1.9. One door shall be exempt from these Requirements.

Exceptions:

1. When the exterior wall(s) is comprised of steel stud framing members, the procedure contained in Section 4.2.2.1.1.1 shall be used to adjust the *U*-factor of the opaque sections of such walls prior to selection of the appropriate acceptable practice(s).
2. When the thermal mass of the exterior building walls is considered, the procedure contained in Section 4.2.2.1.1.2 shall be used to adjust the *U*-factor of the opaque sections of such walls prior to the selection of the appropriate acceptable practice(s).

4.2.2.3.2 **Roof/ceiling.** The roof/ceiling assembly shall be selected for a thermal transmittance value not exceeding the value specified for roofs/ceilings in Table 4.2.2.

Exception: When the roof/ceiling is comprised of assemblies containing truss type or C-shaped, cold-formed steel-framing members, the procedure outlined in Section 4.2.2.1.2 shall be used to adjust the roof/ceiling *U*-factor before selecting a roof/ceiling assembly.

4.2.2.3.3 **Floors over unconditioned spaces.** The floor section over an unconditioned space shall be selected for the overall thermal transmittance factor (U_o) not exceeding the value specified for floors over unconditioned spaces in Table 4.2.2. For floors over outdoor air (i.e., overhangs), U_o-factors for heating shall meet the same requirement as shown for roofs/ceilings in Table 4.2.2.

Exception: When the floor is comprised of C-shaped, cold-formed steel-framing members, the procedure outlined in Section 4.2.2.1.3 shall be used to adjust the floor *U*-factor.

4.2.2.3.4 **Slab-on-grade floors.** Slab-on-grade floors shall meet the provisions of Table 4.2.2 as determined by Section 4.2.2.1.4.

4.2.2.3.5 **Crawl space walls.** Where the floor above a crawl space does not meet the requirements of Section 4.2.2.3.3 and the crawl space does not have Ventilation openings that communicate directly with the outside air, then the exterior walls of the crawl space shall have a thermal transmittance value not exceeding the value given in Table 4.2.2. The *U*-factor of the exterior crawl space wall shall be determined by selecting the *U*-factor for the appropriate crawl space wall section. Where the inside ground surface is 30 cm or greater below the outside finish ground level, insulation shall extend from the top of the wall to at least the inside ground surface. Where the inside ground surface is less than 30 cm below the outside finish ground level, insulation shall extend from the top of the crawl space wall to the top of the footing [see the DOE *Foundation Design Handbook*].

4.2.2.3.6 **Basement walls.** The exterior walls of conditioned basements shall have a thermal transmittance value not exceeding the value given in Table 4.2.2 from the top of the basement wall to a depth of 3 m below grade, or to the level of the basement floor, whichever is less.

4.2.2.4 **Compliance by prescriptive specification on an individual component basis.** For buildings with a window area less than or equal to 8 percent, 12 percent, 15 percent, 18 percent, 20 percent or 25 percent (detached one- and two-family

dwellings) or 20 percent, 25 percent or 30 percent (Group R-2, R-4 or townhouse residential buildings) of the gross exterior wall area, the thermal resistance of insulation applied to the opaque building envelope components shall be greater than or equal to the minimum *R*-values, and the area-weighted average thermal transmittance (*U*-factor) of all fenestration assemblies (other than opaque doors which are governed by Section 4.2.2.4.6) shall be less than or equal to the maximum *U*-factors shown in Table 4.2.2.4(1), 4.2.2.4(2), 4.2.2.4(3), 4.2.2.4(4), 4.2.2.4(5), 4.2.2.4(6), 4.2.2.4(7), 4.2.2.4(8), or 4.2.2.4(9), as applicable. Sections 4.2.2.4.1 through 4.2.2.4.19 shall apply to the use of these tables.

4.2.2.4.1 **Walls.** The sum of the thermal resistance of cavity insulation plus insulating sheathing (if used) shall meet or exceed the "Exterior wall *R*-value."

4.2.2.4.2 **Window area.** The actual window area of a proposed design shall be computed using the rough opening area of all skylights, above-grade windows and, where the basement is conditioned space, any basement windows.

4.2.2.4.3 **Window area, exempt.** One percent of the total window area computed under Section 4.2.2.4.3 shall be exempt from the "Glazing *U*-factor" requirement.

TABLE 4.2.2.4(1)
PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, DETACHED ONE- AND TWO-FAMILY DWELLINGS WINDOW AREA 8 PERCENT OF GROSS EXTERIOR WALL AREA

Degree Days	Maximum	Minimum					
	Glazing *U*-Factor $W/m^2 \cdot K$	Ceiling *R*-value	Exterior wall *R*-value	Floor *R*-value	Basement wall *R*-value	Slab perimeter *R*-value and depth	Crawl space wall *R*-value
0-279	Any	R-2.3	R-1.9	R-1.9	R-0	R-0	R-0
280-559	Any	R-3.3	R-1.9	R-1.9	R-0	R-0	R-0.7
560-829	Any	R-3.3	R-1.9	R-1.9	R-0	R-0	R-0.9
830-1109	Any	R-3.3	R-1.9	R-1.9	R-0.9	R-0	R-0.9
1110-1389	5.11	R-3.3	R-1.9	R-1.9	R-0.9	R-0	R-1
1390-1669	3.98	R-4.6	R-1.9	R-1.9	R-0.9	R-0	R-1
1670-1949	3.98	R-4.6	R-1.9	R-2.3	R-0.9	R-0	R-1
1950-2219	3.69	R-5.3	R-1.9	R-2.3	R-1	R-0.35, 0.6m	R-1.2
2220-2499	3.35	R-5.3	R-1.9	R-2.6	R-1.4	R-0.35, 0.6m	R-1.6
2500-2779	3.13	R-5.3	R-2.3	R-2.6	R-1.4	R-0.35, 0.6m	R-2.1
2780-3059	2.95	R-5.3	R-2.3	R-3.3	R-1.6	R-1.23, 0.6 m	R-2.8
3050-3339	2.56	R-6.7	R-2.3	R-3.3	R-1.6	R-1.23, 0.6 m	R-2.8
3340-3609	2.56	R-6.7	R-2.8	R-3.3	R-1.76	R-1.23, 0.6 m	R-2.8
3610-3889	2.44	R-6.7	R-2.8	R-3.3	R-1.76	R-1.23, 0.6 m	R-2.8
3890-4729	2.39	R-6.7	R-2.8	R-3.3	R-1.9	R-1.4, 1.2 m	R-2.8
4730-4999	2.39	R-6.7	R-2.8	R-3.3	R-2.8	R-1.4, 1.2 m	R-2.8
5000-7229	2.39	R-6.7	R-2.8	R-3.3	R-2.8	R-1.9, 1.2 m	R-2.8

TABLE 4.2.2.4(2)
PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, DETACHED ONE- AND TWO-FAMILY DWELLINGS WINDOW AREA 12 PERCENT OF GROSS EXTERIOR WALL AREA

Degree Days	Maximum	Minimum					
	Glazing *U*-Factor	Ceiling *R*-value	Exterior wall *R*-value	Floor *R*-value	Basement wall *R*-value	Slab perimeter *R*-value and depth	Crawl space wall *R*-value
0-279	Any	R-2.3	R-1.9	R-1.9	R-0	R-0	R-0
280-559	Any	R-3.3	R-1.9	R-1.9	R-0	R-0	R-0.7
560-829	4.26	R-3.3	R-1.9	R-1.9	R-0	R-0	R-0.9
830-1109	4.26	R-3.3	R-1.9	R-1.9	R-0.7	R-0	R-0.9
1110-1389	3.69	R-3.3	R-2.3	R-1.9	R-0.9	R-0	R-0.9
1390-1669	3.41	R-4.6	R-2.3	R-2.3	R-0.9	R-0	R-1.1
1670-1949	3.41	R-5.3	R-2.3	R-2.6	R-1.1	R-0	R-1.8
1950-2219	3.41	R-5.3	R-2.3	R-3.3	R-1.4	R-0.7 0.6 m	R-2.1
2220-2499	3.13	R-6.7	R-2.3	R-3.3	R-1.6	R-0.7 0.6 m	R-2.8
2500-2779	2.84	R-6.7	R-2.5	R-3.3	R-1.6	R-0.9 0.6 m	R-2.8
2780-3059	2.56	R-6.7	R-2.8	R-3.3	R-1.6	R-1.1 0.6 m	R-2.8
3050-3339	2.56	R-6.7	R-3.0	R-3.3	R-1.6	R-1.1 0.6 m	R-2.8
3340-3609	2.27	R-6.7	R-3.2	R-3.3	R-1.8	R-1.1 1.2 m	R-2.8
3610-3889	2.27	R-8.6	R-3.7	R-3.3	R-1.8	R-1.2, 0.6 m	R-3.0
3890-4729	2.27	R-8.6	R-3.7	R-3.3	R-1.8	R-1.6 1.2 m	R-3.0
4730-4999	2.27	R-8.6	R-3.7	R-3.3	R-2.8	R-1.6 1.2 m	R-3.0
5000-7229	2.27	R-8.6	R-3.7	R-3.3	R-2.8	R-19,1.2 m	R-3.0

1 foot = 304.8 mm, 1 hr ft^2 · °F/Btu = 0.1761 m^2 · K/W, 1 Btu/hr ft^2 · °F = 5.678 W/m^2 · K

TABLE 4.2.2.4(3)
PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, DETACHED ONE- AND TWO-FAMILY DWELLINGS WINDOW AREA 15 PERCENT OF GROSS EXTERIOR WALL AREA

Degree Days	Maximum	Minimum					
	Glazing *U*-Factor	Ceiling *R*-value	Exterior wall *R*-value	Floor *R*-value	Basement wall *R*-value	Slab perimeter *R*-value and depth	Crawl space wall *R*-value
0-279	Any	R-2.3	R-1.9	R-1.9	R-0	R-0	R-0
280-559	5.11	R-3.3	R-1.9	R-1.9	R-0	R-0	R-0.7
560-829	4.26	R-3.3	R-1.9	R-1.9	R-0	R-0	R-0.9
830-1109	4.26	R-4.6	R-2.3	R-1.9	R-0.9	R-0	R-0.9
1110-1389	3.69	R-5.3	R-2.3	R-1.9	R-0.9	R-0	R-1.1
1390-1669	3.41	R-5.3	R-2.3	R-3.3	R-1.1	R-0.7, 0.6 m	R-1.2
1670-1949	3.13	R-5.3	R-2.3	R-3.3	R-1.2	R-0.7, 0.6 m	R-1.4
1950-2219	2.84	R-5.3	R-2.3	R-3.3	R-1.4	R-0.9 0.6 m	R-1.8
2220-2499	2.56	R-6.7	R-2.3	R-3.3	R-1.4	R-0.9 0.6 m	R-1.9
2500-2779	2.56	R-6.7	R-2.8	R-3.3	R-1.6	R-1.1 0.6 m	R-0.5
2780-3059	2.56	R-6.7	R-3.2	R-3.3	R-1.6	R-1.1 0.6 m	R-0.5
3050-3339	2.27	R-6.7	R-3.2	R-3.7	R-1.8	R-1.6 0.6 m	R-3.3
3340-3609	2.00	R-6.7	R-3.2	R-3.7	R-1.8	R-1.6, 1.2 m	R-3.5
3610-3889	2.00	R-8.6	R-3.7	R-3.7	R-1.9	R-1.9,1.2 m	R-3.5
3890-4729	2.00	R-8.6	R-3.7	R-3.7	R-1.9	R-2.3,1.2 m	R-3.5
4730-4999	2.00	R-8.6	R-3.7	R-3.7	R-3.2	R-2.5,1.2 m	R-3.5
5000-7229	2.00	R-8.6	R-3.7	R-3.7	R-3.3	R-3.2,1.2 m	R-3.5

1 foot = 304.8 mm, 1 hr ft^2 · °F/Btu = 0.1761 m^2 · K/W, 1 Btu/hr ft^2 · °F = 5.678 W/m^2 · K

TABLE 4.2.2.4(4)
PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, DETACHED ONE- AND TWO-FAMILY DWELLINGS WINDOW AREA 18 PERCENT OF GROSS EXTERIOR WALL AREA

Degree Days	Maximum	Minimum					
	Glazing *U*-Factor	Ceiling *R*-value	Exterior wall *R*-value	Floor *R*-value	Basement wall *R*-value	Slab perimeter *R*-value and depth	Crawl space wall *R*-value
0-279	4.55	R-3.3	R-1.9	R-1.9	R-0	R-0	R-0
280-559	4.26	R-3.3	R-1.9	R-1.9	R-0	R-0	R-0.7
560-829	3.98	R-4.6	R-2.3	R-1.9	R-0	R-0	R-0.9
830-1109	3.69	R-5.3	R-2.3	R-1.9	R-0.9	R-0	R-0.9
1110-1389	3.13	R-5.3	R-2.3	R-1.9	R-0.9	R-0	R-1.1
1390-1669	2.95	R-5.3	R-2.3	R-3.3	R-1.1	R-0	R-1.2
1670-1949	2.84	R-6.7	R-2.3	R-3.3	R-1.2	R-0	R-1.4
1950-2219	2.61	R-6.7	R-2.3	R-3.3	R-1.4	R-1.1,0.6 m	R-1.9
2220-2499	2.27	R-6.7	R-2.3	R-3.3	R-1.6	R-1.1 0.6 m	R-2.3
2500-2779	2.10	R-6.7	R-2.6	R-3.3	R-1.6	R-1.1 0.6 m	R-2.8
2780-3059	2.10	R-6.7	R-2.8	R-3.3	R-1.6	R-1.2 0.6 m	R-3.0
3050-3339	2.10	R-6.7	R-3.3	R-3.3	R-1.8	R-1.4 0.6 m	R-3.0
3340-3609	1.93	R-8.6	R-3.9	R-3.3	R-1.8	R-1.4, 1.2 m	R-3.0
3610-3889	1.88	R-8.6	R-3.9	R-4.4	R-1.9	R-2.5,1.2 m	R-3.3
3890-4729	1.88	R-8.6	R-4.4	R-5.3	R-2.6	Note a	R-4.4
4730-4999	1.88	R-8.6	R-4.4	R-5.3	R-3.3	Note a	R-4.4
5000-7229	1.88	R-8.6	R-4.4	R-5.3	R-3.3	Note a	R-4.4

1 foot = 304.8 mm, 1 hr $ft^2 \cdot {}^oF$/Btu = 0.1761 $m^2 \cdot$ K/W, 1 Btu/hr $ft^2 \cdot {}^oF$=5.678 $W/m^2 \cdot$ K
a. See Section 4.2.2.4.13

TABLE 4.2.2.4(5)
PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, DETACHED ONE- AND TWO-FAMILY DWELLINGS WINDOW AREA 20 PERCENT OF GROSS EXTERIOR WALL AREA

Degree Days	Maximum	Minimum					
	Glazing *U*-Factor	Ceiling *R*-value	Exterior wall *R*-value	Floor *R*-value	Basement wall *R*-value	Slab perimeter *R*-value and depth	Crawl space wall *R*-value
0-279	4.55	R-3.3	R-1.9	R-1.9	R-0	R-0	R-0
280-559	4.26	R-5.3	R-2.3	R-1.9	R-0	R-0	R-0.7
560-829	3.98	R-5.3	R-2.3	R-1.9	R-0	R-0	R-0.9
830-1109	3.41	R-5.3	R-2.3	R-1.9	R-0.9	R-0	R-0.9
1110-1389	2.95	R-6.7	R-2.3	R-1.9	R-0.9	R-0	R-1.1
1390-1669	2.84	R-6.7	R-2.3	R-3.3	R-1.1	R-0	R-1.2
1670-1949	2.61	R-6.7	R-2.3	R-3.3	R-1.2	R-0	R-1.6
1940-2219	2.39	R-6.7	R-2.3	R-3.3	R-1.4	R-1.1,0.6 m	R-1.8
2220-2499	2.10	R-6.7	R-2.3	R-3.3	R-1.6	R-1.1 0.6 m	R-2.3
2400-2779	2.10	R-6.7	R-2.8	R-3.3	R-1.6	R-1.1 0.6 m	R-2.8
2780-3059	2.05	R-6.7	R-3.3	R-3.3	R-1.6	R-1.1 0.6 m	R-2.8
3040-3339	1.88	R-8.6	R-3.5	R-3.3	R-1.8	R-1.2 0.6 m	R-3.0
3340-3609	1.76	R-8.6	R-4.2	R-3.3	R-1.8	R-1.2, 1.2 m	R-3.0
3610-3889	1.70	R-8.6	R-4.6	R-3.7	R-1.9	R-1.8,1.2 m	R-3.0
3890-4729	1.70	R-8.6	R-4.6	R-3.7	R-1.9	R-2.1,1.2 m	R-3.3
4730-4999	1.70	R-8.6	R-4.6	R-3.7	R-3.3	R-2.1,1.2 m	R-3.3
4000-7229	1.70	R-8.6	R-4.6	R-3.7	R-3.3	R-2.8,1.2 m	R-3.3

1 foot = 304.8 mm, 1 hr $ft^2 \cdot {}^oF$/Btu = 0.1761 $m^2 \cdot$ K/W, 1 Btu/hr $ft^2 \cdot {}^oF$=5.678 $W/m^2 \cdot$ K

TABLE 4.2.2.4(6)
PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, DETACHED ONE- AND TWO-FAMILY DWELLINGS WINDOW AREA 25 PERCENT OF GROSS EXTERIOR WALL AREA

Degree Days	Maximum	Minimum					
	Glazing *U*-Factor	Ceiling *R*-value	Exterior wall *R*-value	Floor *R*-value	Basement wall *R*-value	Slab perimeter *R*-value and depth	Crawl space wall *R*-value
0-279	3.98	R-5.3	R-1.9	R-1.9	R-0	R-0	R-0
280-559	3.69	R-5.3	R-2.3	R-1.9	R-0	R-0	R-0.7
560-829	3.13	R-5.3	R-2.3	R-1.9	R-0	R-0	R-0.9
830-1109	2.95	R-5.3	R-2.3	R-2.3	R-1.1	R-0	R-1.1
1110-1389	2.84	R-6.7	R-2.3	R-3.3	R-1.4	R-0	R-1.8
1390-1669	2.61	R-6.7	R-2.8	R-3.3	R-1.1	R-0	R-1.2
1670-1949	2.56	R-6.7	R-3.3	R-3.3	R-1.2	R-0	R-1.6
1940-2219	2.33	R-6.7	R-3.3	R-3.3	R-1.4	R-1.1,0.6 m	R-1.8
2220-2499	2.10	R-6.7	R-3.3	R-3.3	R-1.6	R-1.1 0.6 m	R-2.3
2400-2779	1.88	R-6.7	R-3.3	R-3.3	R-1.6	R-1.1 0.6 m	R-3
2780-3059	1.65	R-6.7	R-3.3	R-3.3	R-1.6	R-1.1 0.6 m	R-3
3040-3339	1.53	R-6.7	R-3.3	R-3.7	R-1.8	Note a	R-3.9
3340-3609	1.42	R-8.6	R-3.3	R-3.7	R-1.8	R-1.6, 1.2 m	R-3.5
3610-3889	1.42	R-8.6	R-3.3	R-5.3	R-2.5	Note a	Note a
3890-4729	1.42	R-8.6	R-3.3	R-5.3	R-2.6	Note a	Note a
4730-4999	1.42	R-8.6	R-3.3	R-5.3	R-28	Note a	Note a
4000-7229	1.42	R-8.6	R-3.3	R-5.3	R-28	Note a	Note a

1 foot = 304.8 mm, 1 hr $ft^2 \cdot {}^oF$/Btu = 0.1761 $m^2 \cdot$ K/W, 1 Btu/hr ft $^2 \cdot {}^oF$ = 5.678 $W/m^2 \cdot$ K
a: See Section 5.2.2.4.12.

TABLE 4.2.2.4(7)
PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, GROUP R-2, R-4 TOWNHOUSE RESIDENTIAL BUILDINGS WINDOW AREA 20 PERCENT OF GROSS EXTERIOR WALL AREA

Degree Days	Maximum	Minimum					
	Glazing *U*-Factor	Ceiling *R*-value	Exterior wall *R*-value	Floor *R*-value	Basement wall *R*-value	Slab perimeter *R*-value and depth	Crawl space wall *R*-value
0-279	Any	R-2.3	R-1.9	R-1.9	R-0	R-0	R-0
280-559	Any	R-3.3	R-1.9	R-1.9	R-0	R-0	R-0.9
560-829	Any	R-3.3	R-1.9	R-1.9	R-0	R-0	R-0.9
830-1109	4.83	R-3.3	R-1.9	R-1.9	R-0.9	R-0	R-0.9
1110-1389	4.00	R-3.3	R-1.9	R-1.9	R-0.9	R-0	R-0.9
1390-1669	3.13	R-5.3	R-2.3	R-1.9	R-0.9	R-0	R-0.9
1670-1949	3.13	R-5.3	R-2.3	R-1.9	R-0.9	R-0	R-0.9
1950-2219	3.13	R-5.3	R-2.3	R-1.9	R-0.9	R-0	R-0.9
2220-2499	3.13	R-6.7	R-2.3	R-1.9	R-0.9	R-0	R-0.9
2500-2779	2.84	R-4.6	R-1.9	R-1.9	R-1.1	R-0	R-1.2
2780-3059	2.84	R-4.6	R-2.3	R-2.3	R-0.9	R-0	R-1.1
3050-3339	2.84	R-5.3	R-2.3	R-1.9	R-0.9	R-0	R-1.1
3340-3609	2.84	R-4.6	R-2.3	R-1.9	R-1.6	R-0.9, 1.2 m	R-2.5
3610-3889	2.56	R-5.3	R-2.3	R-3.3	R-1.8	R-1.2, 1.2 m	R-2.8
3890-4729	2.00	R-6.7	R-2.8	R-3.3	R-1.9	R-1.6, 1.2 m	R-3.2
4730-4999	2.00	R-6.7	R-2.8	R-3.3	R-3	R-1.8,1.2 m	R-3.2
5000-7229	Note a	Note a	Note a	Note a	Note a	Note a	Note a

1 foot = 304.8 mm, 1 hr $ft^2 \cdot {}^oF$/Btu = 0.1761 $m^2 \cdot$ K/W, 1 Btu/hr $ft^2 \cdot {}^oF$ = 5.678 $W/m^2 \cdot$ K
a. See Section 4.2.2.4.12.

TABLE 4.2.2.4(8)
PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, GROUP R-2, R-4 TOWNHOUSE RESIDENTIAL BUILDINGS WINDOW AREA 25 PERCENT OF GROSS EXTERIOR WALL AREA

Degree Days	Maximum	Minimum					
	Glazing *U*-Factor	Ceiling *R*-value	Exterior wall *R*-value	Floor *R*-value	Basement wall *R*-value	Slab perimeter *R*-value and depth	Crawl space wall *R*-value
0-279	Any	R-2.3	R-1.9	R-1.9	R-0	R-0	R-0
280-559	Any	R-3.3	R-1.9	R-1.9	R-0	R-0	R-0.9
560-829	Any	R-3.3	R-1.9	R-1.9	R-0	R-0	R-0.9
830-1109	4.83	R-3.3	R-1.9	R-1.9	R-0.9	R-0	R-0.9
1110-1389	4.00	R-3.3	R-1.9	R-1.9	R-0.9	R-0	R-0.9
1390-1669	3.13	R-5.3	R-2.3	R-1.9	R-0.9	R-0	R-0.9
1670-1949	3.13	R-5.3	R-2.3	R-1.9	R-0.9	R-0	R-0.9
1950-2219	3.13	R-5.3	R-2.3	R-1.9	R-0.9	R-0	R-0.9
2220-2499	3.07	R-5.3	R-2.3	R-1.9	R-0.9	R-0	R-0.9
2500-2779	3.01	R-5.3	R-1.9	R-1.9	R-0.9	R-0	R-1.1
2780-3059	2.95	R-5.3	R-2.3	R-1.9	R-0.9	R-0	R-1.1
3050-3339	2.90	R-5.3	R-2.3	R-1.9	R-1.1	R-0	R-1.1
3340-3609	2.90	R-5.3	R-2.3	R-3.3	R-1.8	R-1.2, 1.2 m	R-2.8
3610-3889	2.56	R-5.3	R-2.3	R-3.3	R-1.8	R-1.2, 1.2 m	R-2.8
3890-4729	2.00	R-6.7	R-2.8	R-3.3	R-1.9	R-1.6, 1.2 m	R-3.2
4730-4999	2.00	R-6.7	R-2.8	R-3.3	R-3	R-1.8,1.2 m	R-3.2
5000-7229	Note a	Note a	Note a	Note a	Note a	Note a	Note a

1 foot = 304.8 mm, 1 hr ft^2 · °F/Btu = 0.1761 m^2 · K/W, 1 Btu/hr ft^2 · °F = 5.678 W/m^2 · K
a: See Section 4.2.2.4.12.

TABLE 4.2.2.4(9)
PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, GROUP R-2, R-4 TOWNHOUSE RESIDENTIAL BUILDINGS WINDOW AREA 30 PERCENT OF GROSS EXTERIOR WALL AREA

Degree Days	Maximum	Minimum					
	Glazing *U*-Factor	Ceiling *R*-value	Exterior wall *R*-value	Floor *R*-value	Basement wall *R*-value	Slab perimeter *R*-value and depth	Crawl space wall *R*-value
0-279	5.11	R-2.3	R-1.9	R-1.9	R-0	R-0	R-0
280-559	4.26	R-3.3	R-1.9	R-1.9	R-0	R-0	R-0.5
560-829	3.98	R-3.3	R-1.9	R-1.9	R-0	R-0	R-0.7
830-1109	3.69	R-4.6	R-1.9	R-1.9	R-0.9	R-0	R-0.9
1110-1389	3.24	R-6.7	R-2.3	R-1.9	R-0.9	R-0	R-1.1
1390-1669	2.67	R-6.7	R-2.3	R-3.3	R-1.2	R-0	R-1.4
1670-1949	2.67	R-6.7	R-2.3	R-3.3	R-1.2	R-0	R-1.6
1950-2219	2.61	R-6.7	R-2.3	R-3.3	R-1.4	R-0.7, 0.6 m	R-1.6
2220-2499	2.61	R-6.7	R-2.3	R-3.3	R-1.6	R-1.1, 0.6 m	R-2.3
2500-2779	2.56	R-6.7	R-2.3	R-3.3	R-1.6	R-1.1, 0.6 m	R-2.6
2780-3059	2.56	R-6.7	R-2.3	R-3.3	R-1.8	R-1.4, 0.6 m	R-3.2
3050-3339	2.50	R-6.7	R-2.3	R-3.3	R-1.8	R-1.4,1.2 m	R-3.2
3340-3609	2.50	R-6.7	R-3.3	R-3.3	R-1.8	R-0.9, 1.2 m	R-3.2
3610-3889	2.16	R-6.7	R-3.3	R-3.3	R-1.8	R-1.4, 1.2 m	R-3.2
3890-4729	1.82	R-8.6	R-3.7	R-5.3	R-3.2	Note a	Note a
4730-4999	1.82	R-8.6	R-3.7	R-5.3	Note a	Note a	Note a
5000-7229	Note a	Note a	Note a	Note a	Note a	Note a	Note a

1 foot = 304.8 mm, 1 hr ft^2 · °F/Btu = 0.1761 m^2 · K/W, 1 Btu/hr ft^2 · °F = 5.678 W/m^2 · K
a: See Section 4.2.2.4.12.

4.2.2.4.4 **Truss/rafter construction.** "Ceiling *R*-value" assumes standard truss or rafter construction. Where raised-heel trusses or other construction techniques are employed to obtain the full height of ceiling insulation over the exterior wall top plate, R-5.3 shall be permitted to be used where R-6.7 is required in the table, and R-6.7 shall be permitted to be used where R-8.6 is required.

4.2.2.4.5 **Doors.** Opaque doors in the building envelope shall have a maximum *U*-factor of 2.0. One door shall be exempt from these Requirements.

4.2.2.4.6 **Ceilings.** "Ceiling *R*-value" shall be required for flat or "cathedral" (inclined) ceilings.

4.2.2.4.7 **Floors.** "Floor *R*-value" shall apply to floors over unconditioned spaces. A floor over outside air shall meet the requirement for "Ceiling *R*-value."

4.2.2.4.8 **Basement walls.** Basement wall insulation shall be installed in accordance with Section 4.2.2.1.6.

4.2.2.4.9 **Unheated slabs.** Slab perimeter insulation shall be installed in accordance with Section 4.2.2.1.4.

4.2.2.4.10 **Heated slabs.** R-0.35 shall be added to the "Slab perimeter *R*-value" where the slab is heated.

4.2.2.4.11 **Crawl space walls.** "Crawl space wall *R*-value" shall apply to unventilated crawl spaces only. Crawl space insulation shall be installed in accordance with Section 4.2.2.1.5.

4.2.2.4.12 **Tables not applicable.** The particular climate range indicated by Note a in Tables 4.2.2.4(4), 4.2.2.4(6), 4.2.2.4(7), 4.2.2.4(8) and 4.2.2.4(9) shall not be used with the indicated envelope component(s) to demonstrate compliance under Section 4.2.2.4.

4.2.2.4.13 **Climates greater than 7,220 DD.** These tables shall not be used for climates greater than or equal to 7,220 DD.

4.2.2.4.14 **Fenestration solar heat gain coefficient.** In locations with DD less than 1,950, fenestration products shall also meet the requirements of Section 4.2.1.5.

4.2.2.4.15 **Steel-framed wall construction.** Where steel framing is used in wall construction, the wall assembly shall meet the equivalent wall cavity and sheathing *R*-values in Table 4.2.2.4.15(1) or 4.2.2.4.15(2), based on the "on-center" (o.c.) dimension of the steel studs and the required *R*-value for wood-framed walls determined in accordance with Section 4.2.2.4, and utilizing any combination of cavity and sheathing insulation set off by commas in Table 4.2.2.4.15(1) or 4.2.2.4.15(2).

4.2.2.4.16 **High-mass wall construction.** Exterior walls constructed of high-mass materials having heat capacity greater than or equal to 1 kJ/($m^2 \cdot K$) of exterior wall area shall meet the equivalent insulation *R*-values in Table 4.2.2.4.16(1) or 4.2.2.4.16(2), based on the placement of the insulation, the DD of the building location, and the required *R*-value for wood-framed walls determined in accordance with Section 4.2.2.4.

TABLE 4.2.2.4.15(1)
40-CM O.C. STEEL-FRAMED WALL EQUIVALENT *R*-VALUES

Wood-Framed Wall *R*-Value [a]	Equivalent Steel-Framed Wall Cavity and Sheathing *R*-Value
R-1.9	R-0+R-1.6, R-1.9+R-0.5, R-2.6+R-0.4, R-4.4+R-0, 3.7+R-0.35
R-2.3	R-1.9+R-0.9, R-2.6+R-0.7, R-3.7+R-0.5
R-2.5	R-1.9+R-1.1, R-2.3+R-0.9, R-3.3+R-0.7
R-2.6	R-1.9+R-1.1, R-2.6+R-0.9, R-3.3+R-0.7
R-2.8	R-1.9+R-1.4, R-2.6+R-1.2, R-3.7+R-1.1
R-3.0	R-1.9+R-1.6, R-2.3+R-1.4, R-3.3+R-1.2
R-3.2	R-1.9+R-1.6, R-2.6+R-1.4, R-3.7+R-1.2
R-3.3	R-1.9+R-1.8, R-2.3+R-1.6, R-3.3+R-1.4, R-4.4+R-1.2
R-3.5	R-1.9+R-1.8, R-2.3+R-1.6, R-3.3+R-1.4
R-3.7	R-2.3+R-1.8, R-3.3+R-1.6, R-4.4+R-1.4
R-3.9	R-2.3+R-1.8, R-3.3+R-1.6
R-4.2	R-3.3+R-1.8, R-4.4+R-1.6
R-4.4	R-3.3+R-1.8
R-4.6	R-3.3+R-1.9, R-3.7+R-1.8

1 inch = 25.4 mm, 1 hr $ft^2 \cdot {}^oF$/Btu = 0.1761 $m^2 \cdot K/W$, 1 Btu/hr $ft^2 \cdot {}^oF$ = 5.678 $W/m^2 \cdot K$

a. As required by Section 4.2.2.4 and the tabular entry for "Exterior wall *R*-value" shown in Tables 4.2.2.4(1) through 4.2.2.4(9), as applicable.

TABLE 4.2.2.4.15(2)
60-CM O.C. STEEL FRAMED WALL EQUIVALENT *R*-VALUES

Wood-Framed Wall *R*-Value [a]	Equivalent Steel-Framed Wall Cavity and Sheathing *R*-Value
R-1.9	R-0+R-1.6, R-1.9+R-0.5, R-2.6+R-2, R-4.4+R-0
R-2.3	R-1.9+R-0.7, R-2.6+R-0.5, R-3.3+R-0.35
R-2.5	R-1.9+R-0.9, R-2.3+R-0.7, R-2.6+R-0.5, R-3.7+R-0.35
R-2.6	R-1.9+R-0.9, R-2.3+R-0.7, R-3.3+R-0.5, R-3.7+R-0.35
R-2.8	R-1.9+R-1.2, R-2.3+R-1.1, R-3.3+R-0.9, R-4.4+R-0.7
R-3.0	R-1.9+R-1.4, R-2.3+R-1.2, R-2.6+R-1.1, R-3.7+R-0.9
R-3.2	R-1.9+R-1.4, R-2.3+R-1.2, R-3.3+R-1.1, R-4.4+R-0.9
R-3.3	R-1.9+R-1.6, R-2.3+R-1.4, R-2.6+R-1.2, R-3.7+R-1.1
R-3.5	R-1.9+R-1.6, R-2.3+R-1.4, R-3.3+R-1.2, R-3.7+R-1.1
R-3.7	R-1.9+R-1.6, R-2.6+R-1.4, R-3.7+R-1.2
R-3.9	R-1.9+R-1.8, R-2.3+R-1.6, R-3.3+R-1.4, R-3.7+R-1.2
R-4.2	R-1.9+R-1.8, R-2.6+R-1.6, R-3.3+R-1.4
R-4.4	R-2.3+R-1.8, R-3.3+R-1.6, R-3.7+R-1.4
R-4.6	R-2.6+R-1.8, R-3.3+R-1.6, R-4.4+R-1.4

1 inch = 25.4 mm, 1 hr $ft^2 \cdot {}^oF$/Btu = 0.1761 $m^2 \cdot K/W$, 1 Btu/hr $ft^2 \cdot {}^oF$ = 5.678 $W/m^2 \cdot K$

a. As required by Section 4.2.2.4 and the tabular entry for "Exterior wall *R*-value" shown in Tables 4.2.2.4(1) through 4.2.2.4(9), as applicable.

TABLE 4.2.2.4.16(1)
HIGH-MASS WALL EQUIVALENT *R*-VALUES INSULATION PLACED ON THE EXTERIOR OF THE WALL OR WITH INTEGRAL INSULATION

Wood-Framed Wall *R*-Value[a]	Equivalent High-Mass Wall *R*-Value					
	DD 0-1110	DD 1111-2210	DD 2211-3050	DD 3051-3600	DD 3601-4720	DD > 4720
R-1.9	R-1.1	R-1.1	R-1.2	R-1.4	R-1.6	R-1.8
R-2.3	R-1.1	R-1.1	R-1.4	R-1.6	R-1.8	R-1.9
R-2.5	R-1.1	R-1.2	R-1.4	R-1.6	R-1.8	R-1.9
R-2.6	R-1.2	R-1.2	R-1.4	R-1.6	R-1.8	R-2.1
R-2.8	R-1.2	R-1.2	R-1.4	R-1.6	R-1.9	R-2.1
R-3.0	R-1.2	R-1.2	R-1.6	R-1.8	R-1.9	R-2.3
R-3.2	R-1.2	R-1.2	R-1.6	R-1.8	R-1.9	R-2.3
R-3.3	R-1.4	R-1.6	R-1.8	R-1.9	R-2.3	R-2.6
R-3.5	R-1.4	R-1.6	R-1.8	R-1.9	R-2.3	R-2.8
R-3.7	R-1.4	R-1.6	R-1.8	R-2.1	R-2.5	R-2.8
R-3.9	R-1.4	R-1.6	R-1.8	R-2.1	R-2.5	R-3.0
R-4.1	R-1.6	R-1.6	R-1.9	R-2.1	R-2.5	R-3.0
R-4.2	R-1.6	R-1.6	R-1.9	R-2.1	R-2.5	R-3.0
R-4.4	R-1.6	R-1.8	R-1.9	R-2.3	R-2.6	R-3.2
R-4.6	R-1.6	R-1.8	R-1.9	R-2.3	R-2.6	R-3.2

1 hr $ft^2 \cdot {}^oF$/Btu = 0.1761 $m^2 \cdot$ K/W, 1 Btu/hr $ft^2 \cdot {}^oF$ = 5.678 $W/m^2 \cdot$ K

a. As required by section 4.2.2.4 and the tabular entry for "Exterior wall *R*-value" shown in Tables 4.2.2.4(1) through 4.2.2.4(9), as applicable, 1 hr $ft^2 \cdot {}^oF$/Btu = 0.1761 $m^2 \cdot$ K/W.

TABLE 4.2.2.4.16(2)
HIGH-MASS WALL EQUIVALENT *R*-VALUES INSULATION PLACED ON THE INTERIOR OF THE WALL

Wood-Framed Wall *R*-Value[a]	Equivalent High-Mass Wall *R*-Value					
	DD 0-1110	DD 1111-2220	DD 2211-3050	DD 3051-3600	DD 3601-4720	DD > 4720
R-1.9	R-1.8	R-1.8	R-1.9	R-1.9	R-2.1	R-2.1
R-2.3	R-1.9	R-1.9	R-2.1	R-2.1	R-2.5	R-2.5
R-2.5	R-2.1	R-2.1	R-2.1	R-2.3	R-2.6	R-2.6
R-2.6	R-2.3	R-2.3	R-2.3	R-2.5	R-2.6	R-2.6
R-2.8	R-2.3	R-2.3	R-2.3	R-2.6	R-2.6	R-2.6
R-3.0	R-2.5	R-2.5	R-2.5	R-2.6	R-2.8	R-2.8
R-3.2	R-2.6	R-2.6	R-2.6	R-3.3	R-2.8	R-2.8
R-3.3	R-2.8	R-2.8	R-2.8	R-3.5	R-3.3	R-3.3
R-3.5	R-2.8	R-2.8	R-2.8	R-3.7	R-3.5	R-3.5
R-3.7	R-3.0	R-3.0	R-3.0	R-3.7	R-3.7	R-3.7
R-3.9	R-3.0	R-3.0	R-3.0	R-3.9	R-3.7	R-3.7
R-4.1	R-3.2	R-3.2	R-3.2	R-3.9	R-3.9	R-3.9
R-4.2	R-3.3	R-3.3	R-3.3	R-3.9	R-3.9	R-3.9
R-4.4	R-3.5	R-3.5	R-3.5	R-3.9	R-3.9	R-3.9
R-4.6	R-3.7	R-3.7	R-3.7	R-4.1	R-4.1	R-4.1

1 hr $ft^2 \cdot {}^oF$/Btu = 0.1761 $m^2 \cdot$K/W, 1 Btu/hr $ft^2 \cdot {}^oF$ = 5.678 $W/m^2 \cdot$ K

a. As required by section 4.2.2.4 and the tabular entry for "Exterior wall *R*-value" shown in Tables 4.2.2.4(1) through 4.2.2.4(9), as applicable 1 hr $ft^2 \cdot {}^oF$/Btu = 0.1761 $m^2 \cdot$ K/W.

4.2.2.4.17 **Steel-framed roof/ceiling construction**. When truss-type, cold-formed steel framing is used in roof/ceiling construction, the roof/ceiling assembly shall meet the equivalent insulation *R*-values in Table 4.2.2.4.17(1).

When C-shaped, cold-formed steel framing is used in roof/ceiling construction, the

steel roof/ceiling assembly shall meet the equivalent wood framed U_R-factors in Table 4.2.2.4.17(2).

TABLE 4.2.2.4.17(1)
TRUSS TYPE COLD-FORMED STEEL ROOF/CEILING EQUIVALENT *R*-VALUES[a]

Wood-Framed Roof/Ceiling *R*-Value[b]	Truss Type Cold-Formed Steel Cavity and Continuous Insulation *R*-Value, 60 cm on Center[c]
R-2.3	R-3.3, R-2.3 + R-0.5
R-3.3	R-4.6, R-3.3 + R-0.5
R-4.6	R-6.7, R-4.6 + R-0.5
R-5.3	R-6.7, R-5.3 + R-0.5
R-6.7	R-8.6, R-6.7 + R-0.9
R-8.6	Not applicable

1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 hr ft^2 · °F/Btu = 0.1761 m^2 · K/W, 1 Btu/hr ft^2 · °F = 5.678 W/m^2 · K

a. This table applies to cold-formed, steel-truss roof framing spaced at 60 cm on center and where the penetrations of the truss members through the cavity insulation do not exceed three penetrations of the truss members through the cavity insulation for each 1.2 m length of the truss.
b. As required by Section 4.2.2.4 and the tabular entry for "Ceiling *R*-value" shown in Tables 4.2.2.4(1) through 4.2.2.4(9).
c. The cavity *R*-value requirement is listed first, followed by the continuous insulation *R*-value requirement.

TABLE 4.2.2.4.17(2)
C-SHAPED COLD-FORMED STEEL ROOF/CEILING EQUIVALENT U_R-FACTORS[a]

Framing [b] mm	spacing	R-2.3[c]	R-3.3[c]	R-4.6[c]	R-5.3[c]	R-6.7[c]	R-8.6[c]
Wood Equivalent / Steel		0.44	0.3	0.23	0.2	0.16	0.13
50 × 100	0.4 m o.c.	0.75	0.3	0.22	0.19	0.15	0.12
50 × 150		0.75	0.37	0.26	0.22	0.16	0.13
50 × 200		0.75	0.68	0.33	0.27	0.19	0.14
50 × 250		0.75	0.68	0.62	0.58	0.22	0.16
50 × 300		0.75	0.68	0.62	0.58	0.26	0.17
Wood Equivalent / Steel	0.6 m o.c.	0.42	0.29	0.22	0.19	0.15	0.12
50 × 100		0.64	0.29	0.21	0.18	0.15	0.11
50 × 150		0.64	0.34	0.24	0.2	0.16	0.12
50 × 200		0.64	0.56	0.29	0.24	0.18	0.13
50 × 250		0.64	0.56	0.49	0.46	0.2	0.14
50 × 300		0.64	0.56	0.49	0.46	0.23	0.16

1 inch = 25.4 mm, 1 hr ft^2 · °F/Btu = 0.1761 m^2 · K/W, 1 Btu/hr ft^2 · °F = 5.678 W/m^2 · K

a. Linear interpolation is permitted for determining *U*-factors which are between those given in the table.
b. Applies to steel framing up to a maximum thickness of 1.65 mm (16 gage).
c. As required by Section 4.2.2.4 and the tabular entry for "Ceiling *R*-value" shown in Tables 4.2.2.4(1) through 4.2.2.4(9), as applicable.

4.2.2.4.18 **Steel-framed floor construction.** When C-shaped, cold-formed steel framing is used in floor construction, the steel floor assembly shall meet the equivalent wood framed U_f-factors in Table 4.2.2.4.18.

TABLE 4.2.2.4.18
C-SHAPED COLD-FORMED STEEL FLOOR EQUIVALENT U_f - FACTORS[a]

Framing [b]	spacing	R-1.9[c]	R-2.3[c]	R-2.6[c]	R-3.3[c]	R-3.7[c]	R-4.4[c]	R-5.3
Steel / Wood Equivalent		0.4	0.37	0.34	0.27	0.25	0.21	0.19
50 × 150	0.4 m o.c.	0.6	0.58	0.57	0.33	0.29	NA	NA
50 × 200		0.6	0.58	0.57	0.54	0.53	0.3	NA
50 × 250		0.6	0.58	0.57	0.54	0.53	0.5	0.47
50 × 300		0.6	0.58	0.57	0.54	0.53	0.5	0.47
Steel / Wood Equivalent	0.6 m o.c.	0.4	0.36	0.33	0.37	0.25	0.21	0.18
50 × 150		0.53	0.5	0.49	0.3	0.27	NA	NA
50 × 200		0.53	0.5	0.49	0.46	0.45	0.28	NA
50 × 250		0.53	0.5	0.49	0.46	0.45	0.42	0.4
50 × 300		0.53	0.5	0.49	0.46	0.45	0.42	0.4

1 inch = 25.4 mm, 1 hr $ft^2 \cdot {}^oF/Btu = 0.1761\ m^2 \cdot K/W$, 1 Btu/hr $ft^2 \cdot {}^oF = 5.678\ W/m^2 \cdot K$.
NA = Not applicable.

a. Linear interpolation is permitted for determining *U*-factors which are between those given in the table.
b. Applies to steel framing up to a maximum thickness of 1.65 mm (16 gage).
c. As required by Section 4.2.2.4 and the tabular entry for "Floor *R*-value" shown in Tables 4.2.2.4(1) through 4.2.2.4(9), as applicable.

4.2.2.5 **Prescriptive path for additions and window replacements.** As an alternative to demonstrating compliance with Section 4.2 or 4.2.2, additions with a conditioned floor area less than 45 m^2 to existing single-family residential buildings and structures shall meet the prescriptive envelope component criteria in Table 4.2.2.5 for the designated degree days (DD) applicable to the location. The *U*-factor of each individual fenestration product (windows, doors and skylights) shall be used to calculate an area-weighted average fenestration product *U*-factor for the addition, which shall not exceed the applicable listed values in Table 4.2.2.5. For additions, other than sunroom additions, the total area of fenestration products shall not exceed 40 percent of the gross wall and roof area of the addition. The *R*-values for opaque thermal envelope components shall be equal to or greater than the applicable listed values in Table 4.2.2.5. Replacement fenestration products (where some or all of an existing fenestration unit is replaced with an entire new replacement unit, including the frame, sash and glazing) shall meet the prescriptive fenestration *U*-factor criteria in Table 4.2.2.5 for the designated DD applicable to the location.

Conditioned sunroom additions shall maintain thermal isolation; shall not be used as kitchens or sleeping rooms; and shall be served by a separate heating or cooling system, or be thermostatically controlled as a separate zone of the existing system.

Fenestration products used in additions and as replacement windows in accordance with this section shall also meet the requirements of Section 4.2.1.5 in locations with DD less than 1,920.

Exception: Replacement skylights shall have a maximum *U*-factor of 0.60 when installed in any location above 1,100 DD.

TABLE 4.2.2.5
PRESCRIPTIVE ENVELOPE COMPONENT CRITERIA ADDITIONS TO AND REPLACEMENT WINDOWS FOR EXISTING DETACHED ONE- AND TWO-FAMILY DWELLINGS

Heating Degree Days	Maximum	Minimum					
	Fenestration *U*-Factor	Ceiling *R*-Value [a,e]	Wall *R*-Value[e]	Floor *R*-Value	Basement wall *R*-Value [b]	Slab perimeter *R*-value and depth [c]	Crawl space wall *R*-value [d]
0 - 1109	4.25	R-4.6	R-2.3	R-1.9	R-0.9	R-0	R-0.9
1,110 - 2,229	2.85	R-5.3	R-2.3	R-3.3	R-1.4	R-0.9, 0.6 m.	R-1.8
2,230 - 3,329	2.25	R-6.7	R-3.2	R-3.7	R-1.8	R-1.6, 0.6 m.	R-3.3
3,330 - 4,710	2.00	R-8.6	R-3.7	R-3.7	R-1.9	R-2.3, 1.2 m.	R-3.5
4,720 - 7,220	2.00	R-8.6	R-3.7	R-3.7	R-3.3	R-3.2, 1.2 m.	R-3.5

1 foot = 304.8 mm, 1 hr $ft^2 \cdot {}^oF$/Btu = 0.1761 $m^2 \cdot K/W$, 1 Btu/hr $ft^2 \cdot {}^oF$ = 5.678 $W/m^2 \cdot K$

a. "Ceiling *R*-value" shall be required for flat or inclined ceilings. Floors over outside air shall meet "Ceiling *R*-value" requirements.
b. Basement wall insulation shall be installed in accordance with Section 4.2.2.1.6.
c. Slab perimeter insulation shall be installed in accordance with Section 4.2.2.1.4. An additional R-0.35 shall be added to "Slab perimeter *R*-value" in the table if the slab is heated.
d. "Crawl space wall *R*-value" shall apply to unventilated crawl spaces only. Crawl space insulation shall be installed in accordance with Section 4.2.2.1.5.
e. Sun room additions shall be required to have a maximum fenestration *U*-factor of 0.09 in locations with 1,110-7,220 DD. In locations with 0-3,330 DD, the minimum ceiling *R*-value shall be R-3.3 and the minimum wall *R*-value shall be R-2.3. In locations with 3,330-7,200 DD, the minimum ceiling *R*-value shall be R-4.2 and the minimum wall *R*-value shall be R-2.3.

SECTION 4.3
BUILDING MECHANICAL SYSTEMS AND EQUIPMENT

4.3.1 **General.** This section covers mechanical systems and equipment used to provide heating, ventilating and air-conditioning functions. This section assumes that residential buildings and dwelling units therein will be designed with individual HVAC systems. Where equipment not shown in Table 4.3.2 is specified, it shall meet the provisions of Sections 6.3.2.2 and 6.3.3.2.

4.3.2 **Mechanical equipment efficiency.** Equipment shown in Table 4.3.2 shall meet the specified minimum performance. Data furnished by the equipment supplier, or certified under a nationally recognized certification procedure, shall be used to satisfy these requirements. All such equipment shall be installed in accordance with the manufacturer's instructions.

TABLE 4.3.2
MINIMUM EQUIPMENT PERFORMANCE

Equipment Category	Subcategory	Referenced Standard	Minimum Performance
Air-cooled heat pumps, Heating mode < 19,000 kW cooling capacity	Split systems Single package	(ARI 210/240)	6.8 HSPF[a] 6.6 HSPF[a]
Gas-fired or oil-fired furnace < 66,000 kW	—	Building Foundation Design Handbook	AFUE 78% E_t 80%
Gas-fired or oil-fired steam and hot-water boilers < 88,000 kW	—	Building Foundation Design Handbook	AFUE 80%
Air-cooled air conditioners and heat pumps, Cooling mode < 19,000 kW cooling capacity	Split systems Single package	(ARI 210/240)	10.0 SEER 9.7 SEER

1 British thermal unit per hour = 0.2931 W.

a. For multi-capacity equipment, the minimum performance shall apply to each capacity step provided. Multi-capacity refers to manufacturer-published ratings for more than one capacity mode allowed by the product's controls.

4.3.3 **HVAC systems.** HVAC systems shall meet the criteria set forth in Sections 4.3.3.1 through 4.3.3.3.

4.3.3.1 **Load calculations.** Heating and cooling system design loads for the purpose of sizing systems and equipment shall be determined in accordance with the procedures described in the ASHRAE *Fundamentals Handbook*. Heating and cooling loads shall be adjusted to account for load reductions that are achieved when energy recovery systems are utilized in the HVAC system in accordance with the ASHRAE *HVAC Systems and Equipment Handbook*. Alternatively, design loads shall be determined by an approved equivalent computation procedure, using the design parameters specified in Chapter 2.

4.3.3.2 **Temperature and humidity controls.** Temperature and humidity controls shall be provided in accordance with Sections 4.3.3.2.1 through 4.3.3.2.4.

4.3.3.2.1 **System controls.** Each dwelling unit shall be considered a zone and be provided with thermostatic controls responding to temperature within the dwelling unit. Each heating and cooling system shall include at least one temperature control device.

4.3.3.2.2 **Thermostatic control capabilities.** Where used to control comfort cooling, thermostatic controls shall be capable of being set locally or remotely by adjustment or selection of sensors up to 29°C (85°F) or higher.

Where used to control comfort heating, thermostatic controls shall be capable of being set locally or remotely by adjustment or selection of sensors down to 13°C (55°F) or lower.

Where used to control both comfort heating and cooling, thermostatic controls shall be capable of providing a temperature range or dead band of at least 3°C (5°F) within which the supply of heating and cooling energy is shut off or reduced to a minimum.

Exceptions:

1. Special occupancy or special usage conditions approved by the code official.
2. Thermostats that require manual changeover between heating and cooling modes.

4.3.3.2.3 **Heat pump auxiliary heat.** Heat pumps having supplementary electric resistance heaters shall have controls that prevent heater operation when the heating load is capable of being met by the heat pump. Supplemental heater operation is not allowed except during outdoor coil defrost cycles not exceeding 15 minutes.

4.3.3.2.4 **Humidistat.** Humidistats used for comfort purposes shall be capable of being set to prevent the use of fossil fuel or electricity to reduce relative humidity below 60 percent or increase relative humidity above 30 percent.

4.3.3.3 **Distribution system, construction and insulation.** Distribution systems shall be constructed and insulated in accordance with Sections 4.3.3.3.1 through 4.3.3.3.7.

4.3.3.3.1 **Piping insulation.** All HVAC system piping shall be thermally insulated in accordance with Table 4.3.3.3.1.

Exceptions:

1. Factory-installed piping within HVAC equipment tested and rated in accordance with Section 4.3.2.
2. Piping that conveys fluids which have a design operating temperature range between 13°C and 41°C.
3. Piping that conveys fluids which have not been heated or cooled through the use of fossil fuels or electricity.

TABLE 4.3.3.3.1
MINIMUM INSULATION

Piping System Types	Fluid Temperature Range °C	Pipe Sizes [a]					
		Runouts up to 50 mm (2")[b]	25 mm (1") and less	32–50 mm (1.25" to 2")	65-100 mm (2.5" to 4")	125-150 mm (5" to 6")	200 mm (8") and larger
HEATING SYSTEMS							
Steam and hot water							
High pressure/ temperature	150-230	38 mm (1 1/2")	64 mm (2 1/2")	64 mm (2 1/2")	75 mm (3")	90 mm (3 1/2")	90 mm (3 1/2")
Medium pressure/ temperature	120-150	38 mm (1 1/2")	50 mm (2")	65 mm (2 1/2")	65 mm (2 1/2")	75 mm (3")	75 mm (3")
Low pressure/ temperature	90-120	25 mm (1")	38 mm (1 1/2")	38 mm (1 1/2")	50 mm (2")	50 mm (2")	50 mm (2")
Low temperature	40-90	13 mm (1/2")	25 mm (1")	25 mm (1")	38 mm (1 1/2")	38 mm (1 1/2")	38 mm (1 1/2")
Steam condense (for feed water)	Any	25 mm (1")	25 mm (1")	38 mm (1 1/2")	50 mm (2")	50 mm (2")	50 mm (2")
COOLING SYSTEMS							
Chilled water, refrigerant and brine	4-15	12.5 mm (1/2")	12.5 mm (1/2")	20 mm (3/4")	25 mm (1")	25 mm (1")	25 mm (1")
	Below 4	25 mm (1")	25 mm (1")	38 mm (1 1/2")	38 mm (1 1/2")	38 mm (1 1/2")	38 mm (1 1/2")

a. For piping exposed to outdoor air, increase insulation thickness by 12 mm.
b. Run-outs not exceeding 3.6 m in length to individual terminal units.

4.3.3.3.2 **Other insulation thicknesses.** Insulation thicknesses in Table 4.3.3.3.1 are based on insulation having thermal resistivity in the range of 0.7 to 0.80 $m^2 \cdot K/W$ per 25 mm of thickness on a flat surface at a mean temperature of 24°C.
Minimum insulation thickness shall be increased for materials having values less than 0.7, or shall be permitted to be reduced for materials having thermal resistivity values greater than 0.81 in accordance with Equation 4-15.

$$\frac{0.81 \times Table\,4.3.3.3.1\ \ Thickness}{Actual\ Resistivity} = New\,Minimum\,Thickness \qquad \textbf{(Equation 4-15)}$$

For materials with thermal resistivity values less than 0.7, the minimum insulation thickness shall be permitted to be increased in accordance with Equation 4-16.

$$\frac{0.7 \times Table\,4.3.3.3.1\ \ Thickness}{Actual\ Resistivity} = New\,Minimum\,Thickness \qquad \textbf{(Equation 4-16)}$$

4.3.3.3.3 **Duct and plenum insulation.** All supply and return-air ducts and plenums installed as part of an HVAC air-distribution system shall be thermally insulated in accordance with Table 4.3.3.3.3, or where such ducts or plenums operate at static pressures greater than 500 Pa (5 cm w.g), in accordance with Section 4.3.3.3.4.1.

Exceptions:

1. Factory-installed plenums, casings or duct work furnished as a part of the HVAC equipment tested and rated in accordance with Section 4.3.2.
2. Ducts within the conditioned space that they serve.

TABLE 4.3.3.3.3
MINIMUM DUCT INSULATION [a]

Annual Degree Days	Insulation *R*-Value m² K/W [d]			
	Ducts in unconditioned attics or outside building		Ducts in unconditioned basements, crawl spaces, garages, and other unconditioned spaces [c]	
	Supply	Return	Supply	Return [b]
< 800	1.4	0.70	0.70	0.00
800 to 1899	1.4	0.70	1.00	0.35
1900 to 4150	1.4	0.70	1.40	0.35
> 4150	1.95	1.00	1.95	0.35

a. Insulation *R*-values shown are for the insulation as installed and do not include film resistance. The required minimum *R*-values do not consider water vapor transmission and condensation. Where control of condensation is required, additional insulation, vapor retarders or both shall be provided to limit vapor transmission and condensation. For ducts that are designed to convey both heated and cooled air, duct insulation shall be as required by the most restrictive condition. Where exterior walls are used as plenums, wall insulation shall be as required by the most restrictive condition of this section.
b. Insulation on return ducts in basements is not required.
c. Unconditioned spaces include ventilated crawl spaces and framed cavities in those floors, wall and ceiling assemblies which separate conditioned space from unconditioned space or outside air, and are uninsulated on the side facing away from the condition space.
d. Insulation resistance measured on a horizontal plane in accordance with ASTM C 518, at a mean temperature of 24°C.

4.3.3.3.4 **Duct construction.** Ductwork shall be constructed and erected in accordance with the Saudi Building Code Mechanical Requirements SBC 501.

4.3.3.3.4.1 **High-and medium-pressure duct systems.** All ducts and plenums operating at static pressures greater than 500 Pa (5 cm w.g.) shall be insulated and sealed in accordance with Section 6.3.2.8. Ducts operating at static pressures in excess of 750 Pa (7.5 cm w.g.) shall be leak tested in accordance with Section 6.3.3.6. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the Saudi Building Code Mechanical Requirements SBC 501.

4.3.3.3.4.2 **Low-pressure duct systems.** All longitudinal and transverse joints, seams and connections of supply and return ducts operating at static pressures less than or equal to 500 Pa (5 cm w.g.) shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems or tapes installed in accordance with the manufacturer's installation instructions. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the Saudi Building Code Mechanical Requirements SBC 501.

Exception: Continuously welded and locking type longitudinal joints and seams on ducts operating at static pressures less than 500 Pa (5 cm w.g.) pressure classification.

4.3.3.3.4.3 **Sealing required.** All joints, longitudinal and transverse seams, and connections in ductwork, shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems or tapes. Tapes and mastics used to seal ductwork shall be listed and labeled in accordance with (UL 181A or UL 181B). Duct connections to flanges of air distribution system equipment shall be sealed and mechanically fastened. Unlisted duct tape is not permitted as a sealant on any metal ducts.

4.3.3.3.5 **Mechanical ventilation.** Each mechanical ventilation system (supply or exhaust, or both) shall be equipped with a readily accessible switch or other means for shutoff, or volume reduction and shutoff, when ventilation is not required.

Automatic or gravity dampers that close when the system is not operating shall be provided for outdoor air intakes and exhausts.

4.3.3.3.6 **Transport energy.** The air transport factor for each all-air system shall be not less than 5.5 when calculated in accordance with Equation 4-17. Energy for transfer of air through heat-recovery devices shall not be included in determining the air transport factor.

$$\text{Air Transport Factor} = \frac{\text{Space Sensible Heat Removal}^{a}}{\text{Supply} + \text{Return Fan(s) Power Input}^{a}} \qquad \textbf{(Equation 4-17)}$$

a. Expressed in consistent units, Watts.

For purposes of these calculations, space sensible heat removal is equivalent to the maximum coincident design sensible cooling load of all spaces served for which the system provides cooling. Fan power input is the rate of energy delivered to the fan prime mover.

Air and water, all-water and unitary systems employing chilled, hot, dual temperature or condenser water-transport systems to space terminals shall not require greater transport energy (including central and terminal fan power and pump power) than an equivalent all-air system providing the same space sensible heat removal and having an air transport factor of not less than 5.5.

4.3.3.3.7 **Balancing.** The HVAC system design shall provide means for balancing air and water systems. Balancing mechanisms shall include, but not be limited to, dampers, temperature and pressure test connections, and balancing valves.

SECTION 4.4
SERVICE WATER HEATING

4.4.1 **Scope.** The purpose of this section is to provide criteria for design and equipment selection that will produce energy savings when applied to service water heating. Water supplies to ice-making machines and refrigerators shall be taken from a cold-water line of the water distribution system.

4.4.2 **Water heaters, storage tanks and boilers.** Water heaters, storage tanks and boilers shall meet the performance criteria set forth in Sections 4.4.2.1 and 4.4.2.2.

4.4.2.1 **Performance efficiency.** Water heaters and hot water storage tanks shall meet the minimum performance of water-heating equipment specified in Table 4.4.2.1. Where multiple criteria are listed, all criteria shall be met.

Exception: Storage water heaters and hot water storage tanks having more than 530 L (140 gallons) of storage capacity need not meet the standby loss (*SL*) or heat loss (*HL*) requirements of Table 4.4.2.1 if the tank surface area is thermally insulated to R-2.2 and if a standing plot light is not used.

4.4.2.2 **Combination service water-heating/space-heating boilers.** Service water-heating equipment shall not be dependent on year-round operation of space-heating boilers; that is, boilers that have as another function winter space heating.

Exceptions:

1. Systems with service/space-heating boilers having a standby loss (W) less than that calculated in equation 4-18:

$$SL \le \frac{(13.99 \cdot pmd) + 400}{n} \times 0.2931\ \text{W} \qquad \textbf{(Equation 4-18)}$$

As determined by the fixture count method where:

pmd = Probable maximum demand in cm^3/s as determined in accordance with the ASHRAE *HVAC Applications Handbook*.

n = Fraction of year when outdoor daily mean temperature exceeds 18°C.

The standby loss is to be determined for a test period of 24-hour duration while maintaining a boiler water temperature of 32°C above an ambient of 16 to 32°C and a 1.5 m stack on appliance.

2. For systems where the use of a single heating unit will lead to energy savings, such unit shall be utilized.

TABLE 4.4.2.1
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT

Category	Type	Fuel	Input Rating	V_T[a] (L)	Input to V_T Ratio (kJ h/L)	Test Method	Energy Factor	Thermal Efficiency E_t (percent)	Standby Loss (percent/ hour)[a]
NAECA-covered water-heating equipment [c]	All	Electric	12kW	All [e]	–	Note f	0.93-0.00132V*	–	–
	Storage	Gas	22,000 kW	All [e]	–	Note f	0.62-0.0019V*	–	–
	Instantaneous	Gas	58,500 kW[e]	All	–	Note f	0.62-0.0019V*	–	–
	Storage	Oil	31,000 kW	All	–	Note f	0.59-0.0019V*	–	–
	Instantaneous	Oil	62,000 kW	All	–	Note f	0.59-0.0019V*	–	–
	Pool heater	Gas/oil	All	All	–	Note g	–	78%	–
Other water-heating equipment [d]	Storage	Electric	All	All	–	Note h	–	–	$0.30+27/V_T$*
	Storage/ instantaneous	Gas/Oil	45,000 kW > 45,500 kW	All	< 1115	Note h	–	78%	$3+114/V_T$*
				All	< 1115	Note h	–	78%	$1.3+95/^{V}T$*
				< 37.85 37.85	1115 1115	Note h	–	80% 77%	– $2.3+67/V_T$*
Unfired storage tanks	–	–	–	All	–	–	–	–	20.5 Wh/m^2 [i]*

1 British thermal unit per square foot = 3.155 W/m^2, 1 British thermal unit per hour = 0.2931 W, 1 gallon = 3.785 L.

a. V_T is the storage volume in gallons as measured during the standby loss test. For the purpose of estimating the standby loss requirement using the rated volume shown on the rating plate, V_T should be no less than 0.95V for gas and oil water heaters and no less than 0.90V for electric water heaters.

b. V is rated storage volume in gallons as specified by the manufacturer.

c. Consistent with National Appliance Energy Conservation Act (NAECA) of 1987.

d. All except those water heaters covered by NAECA.

e. Applies to electric and gas storage water heaters with rated volumes 57.7 L and gas instantaneous water heaters with input ratings of 14,500 to 59,000 kW.

f. (DOE CFR 10; Part 430, Subpart B, Appendix E.

g. ANSI Z21.56).

h. (ANSI Z21.10.3) When testing an electric storage water heater for stand by loss using the test procedure of Section 2.9 of (ANSI Z21.10.3), the electrical supply voltage shall be maintained within ±1 percent of the center of the voltage range specified on the water heater nameplate. Also, when needed for calculations, the thermal efficiency (E_t) shall be 98 percent. When testing an oil water heater using the test procedures of Sections 2.8 and 2.9 (ANSI Z21.10.3), the following modifications will be made: A vertical length of the flue pipe shall be connected to the flue gas outlet of sufficient height to establish the minimum draft specified in the manufacturer's installation instructions. All measurements of oil consumption will be taken by instruments with an accuracy of ±1 percent or better. The burner shall be adjusted to achieve an hourly (J) Btu input rate within ±2 percent of the manufacturer's specified input rate with the CO_2 reading as specified by the manufacturer with smoke no greater than 1 and the fuel pump pressure within ±1 percent of the manufacturer's specification.

i. Heat loss of tank surface area (W/m^2) based on 44ºC water-air temperature difference.

* Minimum efficiencies marked with an asterisk are established by preemptive federal law and are printed for the convenience of the user.

4.4.3 **Swimming pools.** Swimming pools shall be provided with energy-conserving measures in accordance with Sections 4.4.3.1 through 4.4.3.3.

4.4.3.1 **On-off switch.** All pool heaters shall be equipped with an ON-OFF switch mounted for easy access to allow shutting off the operation of the heater without adjusting the thermostat setting and to allow restarting without relighting the pilot light.

4.4.3.2 **Pool covers.** Heated swimming pools shall be equipped with a pool cover.

Exception: Outdoor pools deriving more than 20 percent of the energy for heating from renewable sources (computed over an operating season) are exempt from these Requirements.

4.4.3.3 **Time clocks.** Time clocks shall be installed so that the pump can be set to run in the off-peak electric demand period and can be set for the minimum time necessary to maintain the water in a clear and sanitary condition in keeping with applicable health standards.

4.4.4 **Hot water system controls.** Automatic-circulating hot water system pumps or heat trace shall be arranged to be conveniently turned off, automatically or manually, when the hot water system is not in operation.

4.4.5 **Pipe insulation.** For automatic-circulating hot water systems, piping heat loss shall be limited to a maximum of 17 W/m of pipe in accordance with Table 4.4.5, which is based on design external temperature no lower than 18ºC. For external design temperatures lower than 18ºC insulation thickness must be calculated in accordance with Section 4.3.3.3.2.

Exception: Piping insulation is not required when the heat loss of the piping, without insulation, does not increase the annual energy requirements of the building.

TABLE 4.4.5
MINIMUM PIPE INSULATION (THICKNESS IN mm)

Service Water-Heating Temperatures (°C)	Pipe Sizes[a]			
	Noncirculating runouts	Circulating mains and runouts		
	Up to 25	Up to 32	38 to 51	Over 50
75 -82	13	25	38	50
60-76	13	13	25	38
37-60	13	13	12	25

a. Nominal iron pipe size and insulation thickness.

4.4.6 **Conservation of hot water.** Hot water shall be conserved in accordance with Section 4.4.6.1.

4.4.6.1 **Showers.** Shower heads shall have a maximum flow rate of 0.15 L/s at a pressure of 550 kPa when tested in accordance with (ASME A112.18.1).

4.4.7 **Heat traps.** Water heaters with vertical pipe risers shall have a heat trap on both the inlet and outlet of the water heater unless the water heater has an integral heat trap or is part of a circulating system.

SECTION 4.5
ELECTRICAL POWER AND LIGHTING

4.5.1 **Electrical energy consumption.** In residential buildings having individual dwelling units, provisions shall be made to determine the electrical energy consumed by each tenant by separately metering individual dwelling units.

4.5.2 **Lighting power budget.** The lighting system shall meet the applicable provisions of Section 6.5.

Exception: Detached one- and two-family dwellings and town houses and the dwelling portion of Group R-2 and R-4 residential buildings.

CHAPTER 5
SIMPLIFIED PRESCRIPTIVE REQUIREMENTS FOR DETACHED ONE- AND TWO-FAMILY DWELLINGS AND GROUP R-2, R-4 OR TOWNHOUSE RESIDENTIAL BUILDINGS

SECTION 5.1
GENERAL

5.1.1 **Scope.** This chapter sets forth energy-efficiency-related requirements for the design and construction of detached one- and two-family dwellings and Group R-2, R-4 or townhouse residential buildings.

Exception: Portions of the building envelope that do not enclose conditioned space.

5.1.2 **Compliance.** Compliance shall be demonstrated in accordance with Section 5.1.2.1 or 5.1.2.2.

5.1.2.1 **Residential buildings, detached one- and two family dwellings.** Compliance for detached one- and two-family dwellings shall be demonstrated by either:

1. Meeting the requirements of this chapter for buildings with a glazing area that does not exceed 15 percent of the gross area of exterior walls; or

2. Meeting the requirements of Chapter 3, or Chapter 4 for detached one- and two-family dwellings.

5.1.2.2 **Residential buildings, Groups R-2, R-4 or townhouses.** Compliance for Group R-2, R-4 or townhouse residential buildings shall be demonstrated by either:

1. Meeting the requirements of this chapter for buildings with a glazing area that does not exceed 25 percent of the gross area of exterior walls; or

2. Meeting the requirements of Chapter 3, or Chapter 4 for Group R-2, R-4 or townhouse residential buildings.

5.1.3 **Materials and equipment.** Materials and equipment shall be identified in a manner that will allow a determination of their compliance with the applicable provisions of this chapter. Materials and equipment used to conform to the applicable provisions of this chapter shall be installed in accordance with the manufacturer's installation instructions.

5.1.3.1 **Insulation.** The thermal resistance (*R*-value) shall be indicated on all insulation and the insulation installed such that the *R*-value can be verified during inspection, or a certification of the installed *R*-value shall be provided at the job site by the insulation installer. Where blown-in or sprayed insulation is applied in walls, the installer shall provide a certification of the installed density and *R*-value. Where blown-in or sprayed insulation is applied in the roof/ceiling assembly, the installer shall provide a certification of the initial installed thickness, settled thickness, coverage area, and number of bags of insulating material installed. Markers shall be provided for every 30 m^2 of area, attached to the trusses, rafters or joists, and indicate in 25 mm numbers the installed thickness of the insulation.

5.1.3.2 **Fenestration.** The *U*-factor of fenestration shall be determined in accordance with NFRC 100 by an accredited, independent laboratory, and labeled and certified by the manufacturer. The solar heat gain coefficient (SHGC) of fenestration shall be determined in accordance with (NFRC 200) by an accredited, independent laboratory, and labeled and certified by the manufacturer.

5.1.3.2.1 **Default fenestration performance.** Where a manufacturer has not determined a fenestration product's *U*-factor in accordance with NFRC 100, compliance shall be determined by assigning such products a default *U*-factor from Tables 1.2.5.2(1)

and 1.2.5.2(2). When a manufacturer has not determined a fenestration product's SHGC in accordance with (NFRC 200), compliance shall be determined by assigning such products a default SHGC from Table 1.2.5.2(3).

5.1.3.2.2 **Air leakage.** The air leakage of prefabricated fenestration shall be determined in accordance with (AAMA/WDMA 101/I.S.2) or (NFRC 400) by an accredited, independent laboratory, and labeled and certified by the manufacturer and shall not exceed the values in Table 4.2.1.4.1. Alternatively, the manufacturer shall certify that the fenestration is installed in accordance with Section 4.2.1.4.

5.1.3.3 **Maintenance.** Where mechanical or plumbing system components require preventive maintenance for efficient operation, regular maintenance requirements shall be clearly stated and affixed to the component, or the source for such information shall be shown on a label attached to the component.

SECTION 5.2
BUILDING ENVELOPE

5.2.1 **Thermal performance criteria.** The minimum required insulation *R*-value or the area-weighted average maximum required fenestration *U*-factor (other than opaque doors which are governed by Section 5.2.1.3) for each element in the building thermal envelope (fenestration, roof/ceiling, opaque wall, floor, slab edge, crawl space wall and basement wall) should be in accordance with the criteria in Table 5.2.1.

The building envelope requirements of Chapter 3 or 4 shall be used to determine compliance with detached one- and two-family dwellings with greater than 15-percent glazing area; Group R-2, R-4 or townhouse residential buildings with greater than 25-percent glazing area; and any residential building in climates with degree days (DD) equal to or greater than 7230.

Table 5.2.1
Simplified Prescriptive Building Envelope Thermal Component Criteria
Minimum Required Thermal Performance (*U*-Factor and *R*-Value)

Degree Days °C	Maximum	Minimum					
	Glazing U-factor $W/m^2 \cdot K$	Ceiling *R*-value $m^2 \cdot K/W$	Wall *R*-value $m^2 \cdot K/W$	Floor *R*-value $m^2 \cdot K/W$	Basement Wall *R*-value $m^2 \cdot K/W$	Slab Perimeter *R*-value and Depth	Crawl Space Wall *R*-value
0 - 279	Any	R-2.3	R-1.9	R-1.9	R-0	R-0	R-0
280 – 559	5.11	R-3.3	R-1.9	R-1.9	R-0	R-0	R-0.7
560 - 829	4.26	R-3.3	R-1.9	R-1.9	R-0	R-0	R-0.9
830 - 1,109	4.26	R-4.6	R-2.3	R-1.9	R-0.9	R-0	R-0.9
1,110 - 1,389	3.69	R-5.3	R-2.3	R-1.9	R-0.9	R-0	R-1
1,390 - 1,669	3.41	R-5.3	R-2.3	R-3.3	R-1	R-0.7, 610 mm	R-1.2
1,670 - 1,949	3.12	R-5.3	R-2.3	R-3.3	R-1.2	R-0.7, 610 mm	R-1.4
1,950 - 2,219	2.84	R-5.3	R-2.3	R-3.3	R-1.4	R-0.9, 610 mm	R-1.8
2,220 - 2,499	2.56	R-6.7	R-2.3	R-3.3	R-1.4	R-0.9, 610 mm	R-1.9
2,500 - 2,779	2.56	R-6.7	R-2.8	R-3.3	R-1.6	R-1, 610 mm	R-3
2,780 - 3,059	2.56	R-6.7	R-3.2	R-3.3	R-1.6	R-1, 610 mm	R-3
3,060 - 3,339	2.27	R-6.7	R-3.2	R-3.7	R-1.8	R-1.6, 1210 mm	R-3.3
3,340 - 3,609	1.99	R-6.7	R-3.2	R-3.7	R-1.8	R-1.6, 1210 mm	R-3.5
3,610 - 3,889	1.99	R-8.6	R-3.7	R-3.7	R-1.9	R-1.9, 1210 mm	R-3.5
3,890 - 4,729	1.99	R-8.6	R-3.7	R-3.7	R-1.9	R-2.3, 1210 mm	R-3.5
4,730 - 4,999	1.99	R-8.6	R-3.7	R-3.7	R-3.2	R-2.5, 1210 mm	R-3.5
5,000 - 7,229	1.99	R-8.6	R-3.7	R-3.7	R-3.3	R-3.2, 1210 mm	R-3.5

5.2.1.1 **Exterior walls.** The sum of the *R*-values of the insulation materials installed in framing cavities and insulating sheathing (where used) shall meet or exceed the minimum required "Wall *R*-value" in Table 5.2.1. Framing, drywall, structural sheathing or exterior siding materials shall not be considered as contributing, in any way, to the thermal performance of exterior walls. Insulation separated from the conditioned space by a vented space shall not be counted towards the required *R*-value.

5.2.1.1.1 **Mass walls.** Mass walls shall be permitted to meet the criteria in Table 5.2.1.1.1(1) based on the insulation position and the climate zone where the building is located. Other mass walls shall meet the frame wall criteria for the building type and the climate zone where the building is located, based on the sum of interior and exterior insulation. Walls with "exterior insulation" position have the entire effective mass layer interior to an insulation layer. Walls with "integral insulation" position have both insulation and mass materials well mixed as in wood (logs); or substantially equal amounts of mass material on the interior and exterior of insulation as in concrete masonry units with insulated cores or masonry cavity walls. Walls with interior insulation position have the mass material located exterior to the insulating material(s). Walls not meeting the above descriptions for exterior or integral positions shall meet the requirements for "other mass walls" in Table 5.2.1.1.1(1). The *R*-value of the mass assembly for typical masonry construction shall be taken from Table 5.2.1.1.1(2). The mass assembly *R*-value for a solid concrete wall with a thickness of 102 mm or greater is R-1.1. *R*-values for other assemblies are permitted to be based on the hot box tests referenced in (ASTM C 236) or (ASTM C 976), two-dimensional calculations or isothermal plane calculations.

Table 5.2.1.1.1(1)
Mass Wall Prescriptive Building Envelope Requirements

	Mass Wall Assembly *R*-Value [a], $m^2 \cdot K/W$	
	Exterior or Integral Insulation	**Other Mass Walls**
Degree Days, °C	**Residential Buildings**	**Residential Buildings**
0 – 279	R-0.7	R-1.7
280 – 559	R-0.8	R-1.7
560 - 829	R-0.8	R-1.7
830 - 1,109	R-1.4	R-1.9
1,110 - 1,389	R-1.6	R-1.9
1,390 - 1,669	R-1.6	R-1.9
1,670 - 1,949	R-1.6	R-1.9
1,950 - 2,219	R-1.6	R-1.9
2,220 - 2,549	R-1.6	R-1.9
2,500 - 2,779	R-1.8	R-2.2
2,780 - 3,059	R-2.1	R-2.7
3,060 - 3,339	R-2.1	R-2.7
3,340 - 3,609	R-2.1	R-2.7
3,610 - 3,889	R-2.7	R-3.2
3,890 - 4,729	R-2.7	R-3.2
4,730 - 4,999	R-3.2	R-3.2
5,000 - 7,229	R-3.2	R-3.2

a. The sum of the value in Table 5.2.1.1.1(2) and additional insulation layers.

Table 5.2.1.1.1(2)
Mass Assembly *R*-Values, $m^2 \cdot K/W$

Assembly Type	Ungrouted cells, not insulated	Ungrouted Cells Insulated		
		No grout	Vertical cells grouted at 3048 mm o.c. or greater	Vertical cells grouted at less than 3048 mm o.c.
152 mm Lightweight concrete block	0.41	0.88	0.79	0.67
152 mm Medium-weight concrete block	0.40	0.74	0.67	0.56
152 mm Normal-weight concrete block	0.33	0.58	0.55	0.48
203 mm Lightweight concrete block	0.46	1.18	1.04	0.85
203 mm Medium-weight concrete block	0.40	0.93	0.85	0.70
203 mm Normal-weight concrete block	0.36	0.74	0.67	0.58
305 mm Lightweight concrete block	0.51	1.60	1.39	1.11
305 mm Medium-weight concrete block	0.46	1.25	1.13	0.92
305 mm Normal-weight concrete block	0.41	0.99	0.90	0.76
Brick cavity wall	0.65	1.18	1.09	0.95
Hollow clay brick	0.35	0.48	0.46	0.42

5.2.1.1.2 **Steel-frame walls.** The minimum required *R*-values for steel-frame walls shall be in accordance with Table 5.2.1.1.2.

Table 5.2.1.1.2
Steel-Frame Wall Minimum Performance Requirements (*R*-Value)

Degree Days, °C	Equivalent Steel-Frame Wall Cavity and Sheathing *R*-Value[a], $m^2 \cdot K/W$
0 - 1,109	R-1.9 + R-0.9, R-2.6 + R-0.7, R-3.7 + R-0.5
1,110 - 2,219	R-1.9 + R-0.9, R-2.6 + R-0.7, R-3.7 + R-0.5
2,220 - 3,359	R-1.9 + R-1.6, R-2.6 + R-1.4, R-3.7 + R-1.2
3,360 - 4,729	R-2.3 + R-1.8, R-3.3 + R-1.6, R-4.4 + R-1.4
4,730 - 7,229	R-2.3 + R-1.8, R-3.3 + R-1.6, R-4.4 + R-1.4

a. The cavity insulation *R*-value requirement is listed first, followed by the sheathing *R*-value requirement.

5.2.1.2 **Ceilings.** The required "Ceiling *R*-value" in Table 5.2.1 assumes standard truss or rafter construction, and shall apply to all roof/ceiling portions of the building thermal envelope, including cathedral ceilings. Where the construction technique allows the required *R*-value of ceiling insulation to be obtained over the exterior wall top plate, R-5.3 shall be permitted to be used where R-6.7 is required in the table, and R-6.7 shall be permitted to be used where R-8.6 is required.

5.2.1.2.1 **Steel-framed ceiling.** The maximum required U_R-factor for cold-formed steel truss roof/ceiling assemblies shall be in accordance with Table 5.2.1.2.1(1) and compliance shall be determined by using the U_R-factors in Table 5.2.1.2.1(2). This table applies to cold-formed steel truss roof framing spaced at 610 mm on center and where the penetrations of the truss members through the cavity insulation do

not exceed three penetrations for each 1220 mm length of the truss. The maximum required U_R-factor for C-shaped cold-formed steel roof/ceiling assemblies shall be in accordance with Table 5.2.1.2.1(3) and compliance shall be determined by using the U_R-factors in Table 5.2.1.2.1(4).

Table 5.2.1.2.1(1)
Maximum Cold-Formed Steel Roof/Ceiling Truss U_R –Factors

Degree Days, °C	U_R -Factor W/m² · K
0 – 279	0.421
289 – 829	0.286
830 – 1,109	0.213
1,110 – 2,219	0.183
2,220 – 3,609	0.146
3,610 – 7,229	0.117

Table 5.2.1.2.1(2)
Cold-Formed Steel Roof/Ceiling Truss U_R –Factors, W/m² · K

Cavity Insulation *R*-Value	Continuous Insulation Between Drywall and Bottom Chord		
	R-0	R-0.5	R-0.8
R-2.3	0.491	0.350	0.310
R-3.3	0.339	0.265	0.242
R-4.6	0.249	0.207	0.192
R-5.3	0.217	0.184	0.172
R-6.7	0.172	0.151	0.143
R-8.6	0.133	0.120	0.115

Table 5.2.1.2.1(3)
Maximum C-Shaped, Cold-Formed Steel Roof/Ceiling U_R-Factors, W/m² · K

Degree Days, °C	U_R-Factor	
	405 mm o.c.	610 mm o.c.
0 – 279	0.439	0.421
289 – 829	0.305	0.295
830 – 1,109	0.230	0.221
1,110 – 2,219	0.202	0.194
2,220 – 3,609	0.162	0.156
3,610 – 7,229	0.127	0.122

Table 5.2.1.2.1(4)
C-Shaped, Cold-Formed Steel Roof/Ceiling U_R-Factors, W/m² · K

Framing[b] mm	Spacing	R-2.3	R-3.3	R-4.6	R-5.3	R-6.7	R-8.6
50 × 100	405 mm o.c.	0.754	0.301	0.220	0.191	0.151	0.117
50 × 150		0.754	0.379	0.259	0.219	0.168	0.127
50 × 205		0.754	0.686	0.332	0.270	0.196	0.143
50 × 255		0.754	0.686	0.621	0.589	0.226	0.157
50 × 305		0.754	0.686	0.621	0.589	0.267	0.177
50 × 100	610 mm o.c.	0.641	0.290	0.214	0.186	0.148	0.115
50 × 150		0.641	0.346	0.243	0.208	0.161	0.123
50 × 205		0.641	0.564	0.294	0.244	0.182	0.135
50 × 255		0.641	0.564	0.496	0.463	0.203	0.146
50 × 305		0.641	0.564	0.496	0.463	0.229	0.159

a. Linear interpolation is permitted for determining *U*-factors, which are between those given in the table.
b. Applies to steel framing up to a maximum thickness of 1.6mm (16 gage).

5.2.1.3 **Opaque doors.** Opaque doors in the building envelope shall have a maximum *U*-factor of 2 w/m² · K. One opaque door shall be exempt from this *U*-factor requirement.

5.2.1.4 **Floor.** The required *R*-value in Table 5.2.1 shall apply to all floors.

Exception: Any individual floor assembly with more than 25 percent of its conditioned floor area exposed directly to outside air shall meet the *R*-value requirement in Table 5.2.1 for "Ceiling *R*-value."

5.2.1.4.1 **Steel-framed floors.** The maximum required U_f-factor for C-shaped, cold-formed, steel-framed floors shall be in accordance with Table 5.2.1.4.1(1) and compliance shall be determined by using the U_f factors in Table 5.2.1.4.1(2).

Table 5.2.1.4.1(1)
Maximum C-Shaped, Cold-Formed Steel Floor U_f-Factors, W/m² · K

Degree Days	U_f -Factor	
	405 mm o.c.	610 mm o.c.
0 – 1,389	0.412	0.402
1,390 – 3,059	0.271	0.264
3,060 – 7,229	0.257	0.248

Table 5.2.1.4.1(2)
C-Shaped, Cold-Formed Steel Floor U_f– Factors[a], W/m^2 · K

Framing[b] mm	Spacing	R-1.9	R-2.3	R-2.6	R-3.3	R-3.7	R-4.4	R-5.3
50 × 150	405 mm o.c.	0.601	0.585	0.571	0.331	0.297	NA	NA
50 × 205		0.601	0.585	0.571	0.543	0.531	0.311	NA
50 × 255		0.601	0.585	0.571	0.543	0.531	0.508	0.476
50 × 305		0.601	0.585	0.571	0.543	0.531	0.508	0.476
50 × 150	610 mm o.c.	0.534	0.515	0.497	0.306	0.276	NA	NA
50 × 205		0.534	0.515	0.497	0.465	0.450	0.277	NA
50 × 255		0.534	0.515	0.497	0.465	0.450	0.423	0.396
50 × 305		0.534	0.515	0.497	0.465	0.450	0.423	0.396

a. Linear interpolation is permitted for determining *U*-factors, which are between those given in the table.
b. Applies to steel framing up to a maximum thickness of 1.6 mm (16 gage).

5.2.1.5 **Basement walls.** Where the basement is considered a conditioned space, the basement walls shall be insulated in accordance with Table 5.2.1. Where the basement is not considered a conditioned space, either the basement wall or the ceiling(s) separating the basement from conditioned space shall be insulated in accordance with Table 5.2.1. Where basement walls are required to be insulated, the required *R*-value shall be applied from the top of the basement wall to a depth of 3.0 m below grade or to the top of the basement floor, whichever is less.

5.2.1.6 **Slab-on-grade floors.** For slabs with a top edge 305 mm or less below finished grade, the required "Slab perimeter *R*-value and depth" in Table 5.2.1 shall be applied to the outside of the foundation or the inside of the foundation wall. The insulation shall extend downward from the top of the slab or downward from the top of the slab to the bottom of the slab and then horizontally to the interior or exterior, until the distance listed in Table 5.2.1 is reached. Where installed between the exterior wall and the edge of the interior slab, the top edge of the insulation shall be permitted to be cut at a 45-degree (0.79 rad) angle away from the exterior wall. Insulation extending horizontally outside of the foundation shall be protected by pavement or by a minimum of 255 mm of soil. In locations of 280 DD or greater, R-0.34 shall be added to the "Slab perimeter *R*-value" in Table 5.2.1 where uninsulated hot water pipes, air distribution ducts or electric heating cables are installed within or under the slab.

Exception: Slab perimeter insulation is not required for unheated slabs in areas of very heavy termite infestation probability as shown in Figure 5.2.2(7). Where this exception is used, building envelope compliance shall be demonstrated by using Section 5.2.2.2 or Chapter 3 with the actual "Slab perimeter *R*-value and depth" in Table 5.2.1, or by using Section 4.2.2.4.

5.2.1.7 **Crawl space walls.** Where the floor above the crawl space is uninsulated, insulation shall be installed on crawl space walls when the crawl space is not vented to outside air. The required "Crawl space wall *R*-value" in Table 5.2.1 shall be applied inside of the crawl space wall, downward from the sill plate to the exterior finished grade level and then vertically or horizontally or both for 610 mm. The exposed earth in all crawl space foundations shall be covered with a continuous vapor retarder having a maximum permeance rating of 5.7×10^{-11} kg/P·s·m^2, when tested in accordance with (ASTM E 96).

5.2.1.8 **Masonry veneer.** For exterior foundation insulation, the horizontal portion of the foundation which supports a masonry veneer is not required to be insulated.

5.2.1.9 **Protection.** Exposed insulating materials applied to the exterior of foundation walls shall have a rigid, opaque and weather-resistant protective covering. The protective covering shall extend 150 mm below finished grade level.

5.2.1.10 **Caulking, sealants and gasketing.** All joints, seams, penetrations (site-built windows, doors and skylights), openings between window and door assemblies and their respective jambs and framing, and other sources of air leakage (infiltration and exfiltration) through the building envelope shall be caulked, gasketed, weather-stripped, wrapped or otherwise sealed to limit uncontrolled air movement.

5.2.1.11 **Moisture control.** Provisions for moisture control shall be in accordance with Section 4.2.1.1.

5.2.1.12 **Recessed lighting fixtures.** Where provided, recessed lighting fixtures shall be installed in accordance with Section 4.2.1.3.

5.2.2 **Maximum solar heat gain coefficient for fenestration products.** In locations with degree days (DD) less than 1900, the area-weighted-average solar heat gain coefficient (SHGC) for glazed fenestration installed in the building envelope shall not exceed 0.40.

5.2.3 **Fenestration exemption.** Up to 1 percent of the total glazing area shall be exempt from the "Glazing *U*-factor" requirement in Table 5.2.1.

5.2.4 **Replacement fenestration.** Where some or all of an existing fenestration unit is replaced with an entirely new replacement fenestration product, including frame, sash and glazed portion, the replacement fenestration product shall have a *U*-factor that does not exceed the "Fenestration *U*-factor" requirement in Table 4.2.2.5 applicable to the climate zone (DD) where the building is located. The replacement fenestration product(s) must also satisfy the air leakage requirements and SHGC of Sections 5.1.3.2.2 and 5.2.2, respectively.

Exception: Replacement skylights shall have a maximum *U*-factor of 3.4 when installed in any location above 1110 DD.

SECTION 5.3
MECHANICAL SYSTEMS

5.3.1 **Heating and air-conditioning equipment and appliances.** Heating and air-conditioning equipment and appliances shall comply with the applicable requirements of Section 4.3.

SECTION 5.4
SERVICE WATER HEATING

5.4.1 **Water-heating equipment and appliances.** Water heating equipment and appliances shall comply with the applicable requirements of Section 4.4.

SECTION 5.5
ELECTRICAL POWER AND LIGHTING

5.5.1 **Electrical energy consumption.** In residential buildings having individual dwelling units, provisions shall be made to determine the electrical energy consumed by each tenant by separately metering individual dwelling units.

CHAPTER 6
DESIGN BY ACCEPTABLE PRACTICE FOR COMMERCIAL BUILDINGS

SECTION 6.1
GENERAL

6.1.1 **Scope.** The requirements contained in this chapter are applicable to commercial buildings, or portions of commercial buildings. Buildings constructed in accordance with this chapter are deemed to comply with these requirements.

6.1.2 **Application.** The requirements in Sections 6.2, 6.3, 6.4 and 6.5 shall each be satisfied on an individual basis. Where one or more of these sections is not satisfied, compliance for that section(s) shall be demonstrated in accordance with the applicable provisions of (ASHRAE/IESNA 90.1).
Exception: Buildings conforming to Section 6.6, provided Sections 6.2.1.2, 6.2.3, 6.3.2.1 or 6.3.3.1 as applicable, 6.3.2.2 or 6.3.3.2 as applicable, 6.3.2.3 or 6.3.3.3 as applicable, 6.3.2.8 or 6.3.3.6 as applicable, 6.3.2.9 or 6.3.3.7 as applicable, 6.4, 6.5.2, 6.5.3, 6.5.4, 6.5.6 and 6.5.7 are each satisfied.

SECTION 6.2
BUILDING ENVELOPE REQUIREMENTS

6.2.1 **General.** Walls, roof assemblies, floors, glazing and slabs on grade which are part of the building envelope for buildings where the window and glazed door area is not greater than 50 % of the gross area of above-grade walls shall meet the requirements of Sections 6.2.2.1 through 6.2.2.9, as applicable. Buildings with more glazing shall meet the applicable provisions of (ASHRAE/IESNA 90.1).

6.2.1.1 **Classification of walls.** Walls associated with the building envelope shall be classified in accordance with Section 6.2.1.1.1, 6.2.1.1.2 or 6.2.1.1.3.

6.2.1.1.1 **Above-grade walls.** Above-grade walls are those walls covered by Section 6.2.2.1 on the exterior of the building and completely above grade or the above-grade portion of a basement or first-story wall that is more than 15 % above grade.

6.2.1.1.2 **Below-grade walls.** Below-grade walls covered by Section 6.2.2.8 are basement or first-story walls associated with the exterior of the building that are at least 85 % below grade.

6.2.1.1.3 **Interior walls.** Interior walls covered by Section 6.2.2.9 are those walls not on the exterior of the building and that separate conditioned and unconditioned space.

6.2.1.2 **Moisture control.** All framed walls, floors and ceilings not ventilated to allow moisture to escape shall be provided with an approved vapor retarder having a permeance rating of 5.7×10^{-11} $kg/Pa \cdot s \cdot m^2$ or less, when tested in accordance with the desiccant method using Procedure A of (ASTM E 96). The vapor retarder shall be installed on the warm-in-winter side of the insulation.

Exceptions:

1. Buildings located in zones with DD less than 1900 (°C-days).
2. In construction where moisture or its freezing will not damage the materials.
3. Where other approved means to avoid condensation in unventilated framed wall, floor, roof and ceiling cavities are provided.

6.2.2 **Criteria.** The building envelope components shall meet each of the applicable requirements in Tables 6.2.2(1), 6.2.2(2), 6.2.2(3) and 6.2.2(4) based on the percentage of wall that is glazed. The percentage of wall that is glazed shall be determined by dividing the aggregate area of rough openings for glazing (windows and glazed doors) in all above-grade walls associated with the building envelope

by the total gross area of all above-grade exterior walls that are a part of the building envelope. In buildings with multiple types of building envelope construction, each building envelope construction type shall be evaluated separately. Where Table 6.2.2(1), 6.2.2(2), 6.2.2(3) or 6.2.2(4) does not list a particular construction type, the applicable provisions of (ASHRAE/IESNA 90.1) shall be used in lieu of Section 6.2.

6.2.2.1 **Above-grade walls.** The minimum thermal resistance (*R*-value) of the insulating material(s) installed in the wall cavity between the framing members and continuously on the walls shall be as specified in Table 6.2.2(1), 6.2.2(2), 6.2.2(3) or 6.2.2(4), based on framing type and construction materials used in the wall assembly. Where both cavity and continuous insulation values are provided in Table 6.2.2(1), 6.2.2(2), 6.2.2(3) or 6.2.2(4), both requirements shall be met. Concrete masonry units (CMU) at least 200 mm nominal in thickness with essentially equal amounts of mass on either side of the insulation layer are considered as having integral insulation; however, the thermal resistance of that insulation shall not be considered when determining compliance with Table 6.2.2(1), 6.2.2(2), 6.2.2(3) or 6.2.2(4). "Other masonry walls" shall include walls weighing at least 170 kg/m^2 of wall surface area and do not include CMUs less than 200 mm nominal in thickness.

6.2.2.2 **Non-glazed doors.** Non-glazed doors shall meet the applicable requirements for windows and glazed doors and be considered as part of the gross area of above-grade walls that are part of the building envelope.

6.2.2.3 **Windows and glass doors.** The maximum solar heat gain coefficient (SHGC) and thermal transmittance (*U*-factor) of window assemblies and glass doors located in the building envelope shall be as specified in Table 6.2.2(1), 6.2.2(2), 6.2.2(3) or 6.2.2(4), based on the window projection factor. The window projection factor shall be determined in accordance with Equation 6-1.

$$PF = A/B \qquad \textbf{(Equation 6-1)}$$

Where:

PF = Projection factor (decimal).

A = Distance measured horizontally from the furthest continuous extremity of any overhang, eave, or permanently attached shading device to the vertical surface of the glazing.

B = Distance measured vertically from the bottom of the glazing to the underside of the overhang, eave, or permanently attached shading device.

Where different windows or glass doors have different *PF* values, each shall be evaluated separately or an area-weighted *PF* value shall be calculated and used for all windows and glass doors.

6.2.2.4 **Roof assembly.** The minimum thermal resistance (*R*-value) of the insulating material installed either between the roof framing or continuously on the roof assembly shall be as specified in Table 6.2.2(1), 6.2.2(2), 6.2.2(3) or 6.2.2(4), based on construction materials used in the roof assembly.

6.2.2.5 **Skylights.** Skylights located in the building envelope shall be limited to 3 % of the gross roof assembly area and shall have a maximum thermal transmittance (*U*-factor) of the skylight assembly as specified in Table 6.2.2(1), 6.2.2(2), 6.2.2(3) or 6.2.2(4).

6.2.2.6 **Floors over outdoor air or unconditioned space.** The minimum thermal resistance (*R*-value) of the insulating material installed either between the floor framing or continuously on the floor assembly shall be as specified in Table 6.2.2(1), 6.2.2(2), 6.2.2(3) or 6.2.2(4) based on construction materials used in the floor assembly.

6.2.2.7 **Slabs on grade.** The minimum thermal resistance (*R*-value) of the insulation around the perimeter of the slab floor shall be as specified in Table 6.2.2(1), 6.2.2(2), 6.2.2(3) or 6.2.2(4). The insulation shall be placed on the outside of the foundation or on the inside of a foundation wall. The insulation shall extend downward from the top of the slab for a minimum of 1200 mm or downward to at least the bottom of the slab and then horizontally to the interior or exterior for a minimum total distance of 1200 mm.

6.2.2.8 **Below-grade walls.** The minimum thermal resistance (*R*-value) of the insulating material installed in, or continuously on, the below-grade walls shall be as specified in Table 6.2.2(1), 6.2.2(2), 6.2.2(3) or 6.2.2(4) and shall extend to a depth of 3000 mm below the outside finish ground level, or to the level of the floor, whichever is less.

6.2.2.9 **Interior walls.** The minimum thermal resistance (*R*-value) of the insulating material installed in the wall cavity or continuously on the interior walls shall be as specified in Table 6.2.2(1) for above-grade walls, regardless of glazing area, based on framing type and construction materials used in the wall assembly.

6.2.3 **Air leakage**. The requirements for air leakage shall be as specified in Sections 6.2.3.1 and 6.2.3.2.

6.2.3.1 **Window and door assemblies.** The air leakage of window and sliding or swinging door assemblies that are part of the building envelope shall be determined in accordance with (AAMA/WDMA 101/I.S.2) or (101/I.S.2/NAFS-02), (or NFRC 400) by an accredited, independent laboratory, and labeled and certified by the manufacturer and shall not exceed the values in Table 6.2.1.4.1.

Exception: Site-constructed windows and doors that are weather-stripped or sealed in accordance with Section 6.2.3.3.

TABLE 6.2.2(1)
BUILDING ENVELOPE REQUIREMENTS [a through e]
WINDOW AND GLAZED DOOR AREA 10 % OR LESS OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)			
Slab or below-grade wall (*R*-value)			
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25			
0.25 ≤ PF < 0.50			
PF ≥ 0.50			
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss			
Metal joist/truss			
Concrete slab or deck			
Metal purlin with thermal block			
Metal purlin without thermal block			
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss			
Metal joist/truss			
Concrete slab or deck			
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	N A		
R-value continuous	NA		
Concrete masonry units (CMU) ≥ 200 mm: *R*-value cavity	NA		
R-value continuous			
Other masonry walls: *R*-value cavity	NA		
R-value continuous			

a. Values shall be determined from Tables 6.2.2(5) through 6.2.2(23) according to DDs.
b. “NA” indicates the condition is not applicable.
c. An *R*-value of zero indicates no insulation is required.
d. “Any” indicates any available product will comply.
e. “X” indicates no complying option exists for this condition.

TABLE 6.2.2(2)
BUILDING ENVELOPE REQUIREMENTS [a through e]
WINDOW AND GLAZED DOOR AREA GREATER THAN 10 %, BUT NOT GREATER THAN 25 % OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)			
Slab or below-grade wall (*R*-value)			
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25			
0.25 ≤ PF < 0.50			
PF ≥ 0.50			
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss			
Metal joist/truss			
Concrete slab or deck			
Metal purlin with thermal block			
Metal purlin without thermal block			
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss			
Metal joist/truss			
Concrete slab or deck			
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA		
R-value continuous	NA		
Concrete masonry units (CMU) ≥ 200 mm : *R*-value cavity	NA		
R-value continuous			
Other masonry walls: *R*-value cavity	NA		
R-value continuous			

a. Values shall be determined from Tables 6.2.2(5) through 6.2.2(23) according to DDs.
b. "NA" indicates the condition is not applicable.
c. An *R*-value of zero indicates no insulation is required.
d. "Any" indicates any available product will comply.
e. "X" indicates no complying option exists for this condition.

TABLE 6.2.2(3)
BUILDING ENVELOPE REQUIREMENTS [a through e]
WINDOW AND GLAZED DOOR AREA GREATER THAN 25 %, BUT NOT GREATER THAN 40 % OF ABOVE-GRADE WALL AREA

<table>
<tr><th>Element</th><th colspan="3">Condition / Value</th></tr>
<tr><td>Skylights (U-factor)</td><td colspan="3"></td></tr>
<tr><td>Slab or below-grade wall (R-value)</td><td colspan="3"></td></tr>
<tr><td>Windows and Glass doors</td><td colspan="2">Solar Heat Gain Factor (SHGC)</td><td>U-factor</td></tr>
<tr><td>PF < 0.25</td><td colspan="2"></td><td></td></tr>
<tr><td>0.25 ≤ PF < 0.50</td><td colspan="2"></td><td></td></tr>
<tr><td>PF ≥ 0.50</td><td colspan="2"></td><td></td></tr>
<tr><td>Roof assemblies (R-value)</td><td colspan="2">Insulation between framing</td><td>Continuous insulation</td></tr>
<tr><td>All-wood joist/truss</td><td colspan="2"></td><td></td></tr>
<tr><td>Metal joist/truss</td><td colspan="2"></td><td></td></tr>
<tr><td>Concrete slab or deck</td><td colspan="2"></td><td></td></tr>
<tr><td>Metal purlin with thermal block</td><td colspan="2"></td><td></td></tr>
<tr><td>Metal purlin without thermal block</td><td colspan="2"></td><td></td></tr>
<tr><td>Floors over outdoor air or unconditioned space (R-value)</td><td colspan="2">Insulation between framing</td><td>Continuous insulation</td></tr>
<tr><td>All-wood joist/truss</td><td colspan="2"></td><td></td></tr>
<tr><td>Metal joist/truss</td><td colspan="2"></td><td></td></tr>
<tr><td>Concrete slab or deck</td><td colspan="2"></td><td></td></tr>
<tr><td>Above-grade walls (R-value)</td><td>No framing</td><td>Metal framing</td><td>Wood framing</td></tr>
<tr><td>Framed :R-value cavity</td><td>NA</td><td></td><td></td></tr>
<tr><td>R-value continuous</td><td>NA</td><td></td><td></td></tr>
<tr><td>Concrete masonry units (CMU) ≥ 200 mm:
R-value cavity</td><td>NA</td><td></td><td></td></tr>
<tr><td>R-value continuous</td><td></td><td></td><td></td></tr>
<tr><td>Other masonry walls:
R-value cavity</td><td>NA</td><td></td><td></td></tr>
<tr><td>R-value continuous</td><td></td><td></td><td></td></tr>
</table>

a. Values shall be determined from Tables 6.2.2(5) through 6.2.2(23) according to DDs.
b. “NA” indicates the condition is not applicable.
c. An *R*-value of zero indicates no insulation is required.
d. “Any” indicates any available product will comply.
e. “X” indicates no complying option exists for this condition.

TABLE 6.2.2(4)
BUILDING ENVELOPE REQUIREMENTS [a through e]
WINDOW AND GLAZED DOOR AREA GREATER THAN 40 % OF ABOVE-GRADE WALL AREA

Element	**Condition / Value**		
Skylights (*U*-factor)			
Slab or below-grade wall (*R*-value)			
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25			
0.25 ≤ PF < 0.50			
PF ≥ 0.50			
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss			
Metal joist/truss			
Concrete slab or deck			
Metal purlin with thermal block			
Metal purlin without thermal block			
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss			
Metal joist/truss			
Concrete slab or deck			
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA		
R-value continuous	NA		
Concrete masonry units (CMU) ≥ 200 mm: *R*-value cavity	NA		
R-value continuous			
Other masonry walls: *R*-value cavity	NA		
R-value continuous			

a. Values shall be determined from Tables 6.2.2(5) through 6.2.2(23) according to DDs.
b. "NA" indicates the condition is not applicable.
c. An *R*-value of zero indicates no insulation is required.
d. "Any" indicates any available product will comply.
e. "X" indicates no complying option exists for this condition.

TABLE 6.2.2(5)
BUILDING ENVELOPE REQUIREMENTS FOR HDD/CDD (°C) < 278 WINDOW AND GLAZED DOOR AREA 10 % OR LESS OF ABOVE-GRADE WALL AREA

<table>
<tr><th>Element</th><th colspan="3">Condition / Value</th></tr>
<tr><td>Skylights (U-factor)</td><td colspan="3">5.678</td></tr>
<tr><td>Slab or below-grade wall (R-value)</td><td colspan="3">R-0</td></tr>
<tr><td>Windows and Glass doors</td><td colspan="2">Solar Heat Gain Factor (SHGC)</td><td>U-factor</td></tr>
<tr><td>PF < 0.25</td><td colspan="2">Any</td><td>Any</td></tr>
<tr><td>0.25 ≤ PF < 0.50</td><td colspan="2">Any</td><td>Any</td></tr>
<tr><td>PF ≥ 0.50</td><td colspan="2">Any</td><td>Any</td></tr>
<tr><td>Roof assemblies (R-value)</td><td colspan="2">Insulation between framing</td><td>Continuous insulation</td></tr>
<tr><td>All-wood joist/truss</td><td colspan="2">R-2.289</td><td>R-1.937</td></tr>
<tr><td>Metal joist/truss</td><td colspan="2">R-2.289</td><td>R-2.113</td></tr>
<tr><td>Concrete slab or deck</td><td colspan="2">NA</td><td>R-1.937</td></tr>
<tr><td>Metal purlin with thermal block</td><td colspan="2">R-3.346</td><td>R-2.113</td></tr>
<tr><td>Metal purlin without thermal block</td><td colspan="2">R-5.284</td><td>R-2.113</td></tr>
<tr><td>Floors over outdoor air or unconditioned space (R-value)</td><td colspan="2">Insulation between framing</td><td>Continuous insulation</td></tr>
<tr><td>All-wood joist/truss</td><td colspan="2">R-0</td><td>R-0</td></tr>
<tr><td>Metal joist/truss</td><td colspan="2">R-0</td><td>R-0</td></tr>
<tr><td>Concrete slab or deck</td><td colspan="2">NA</td><td>R-0</td></tr>
<tr><td>Above-grade walls (R-value)</td><td>No framing</td><td>Metal framing</td><td>Wood framing</td></tr>
<tr><td>Framed: R-value cavity</td><td>NA</td><td>R-0</td><td>R-0</td></tr>
<tr><td>R-value continuous</td><td>NA</td><td>R-0</td><td>R-0</td></tr>
<tr><td>Concrete masonry units (CMU) ≥ 200 mm:</td><td></td><td></td><td></td></tr>
<tr><td>R-value cavity</td><td>NA</td><td>R-0</td><td>R-0</td></tr>
<tr><td>R-value continuous</td><td>R-0</td><td>R-0</td><td>R-0</td></tr>
<tr><td>Other masonry walls:</td><td></td><td></td><td></td></tr>
<tr><td>R-value cavity</td><td>NA</td><td>R-0</td><td>R-0</td></tr>
<tr><td>R-value continuous</td><td>R-0</td><td>R-0</td><td>R-0</td></tr>
</table>

TABLE 6.2.2(5) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 10 % BUT NOT GREATER THAN 25% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	5.678		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.6		Any
0.25 ≤ PF < 0.50	0.7		Any
PF ≥ 0.50	Any		Any
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.465
Metal joist/truss	R-3.346		R-2.642
Concrete slab or deck	NA		R-2.465
Metal purlin with thermal block	R-4.403		R-2.642
Metal purlin without thermal block	X		R-2.642
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-0		R-0
Metal joist/truss	R-0		R-0
Concrete slab or deck	NA		R-0
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-0	R-0
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0

TABLE 6.2.2(5) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 25 % BUT NOT GREATER THAN 40% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	5.678		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.4		3.975
0.25 ≤ PF < 0.50	0.5		3.975
PF ≥ 0.50	0.6		3.975
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.818
Metal joist/truss	R-4.403		R-2.994
Concrete slab or deck	NA		R-2.818
Metal purlin with thermal block	R-4.403		R-2.994
Metal purlin without thermal block	X		R-2.994
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-0		R-0
Metal joist/truss	R-0		R-0
Concrete slab or deck	NA		R-0
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-0	R-0
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0

TABLE 6.2.2(5) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 40 % BUT NOT GREATER THAN 50% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	5.678		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.3		3.975
0.25 ≤ PF < 0.50	0.4		3.975
PF ≥ 0.50	0.5		3.975
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.818
Metal joist/truss	R-4.403		R-2.994
Concrete slab or deck	NA		R-2.818
Metal purlin with thermal block	R-4.403		R-2.994
Metal purlin without thermal block	R-5.284		R-2.994
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-0		R-0
Metal joist/truss	R-0		R-0
Concrete slab or deck	NA		R-0
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-0	R-0
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0

DD(F) = DD(C)*1.8; 1 W/$m^2 \cdot$ K = 0.1761 BTU/(hr.$ft^2 \cdot$ °F); 1 $m^2 \cdot$ K/W = 5.678 hr.$ft^2 \cdot$ °F/BTU

TABLE 6.2.2(6)

BUILDING ENVELOPE REQUIREMENTS FOR 278 ≤ HDD/CDD (°C) < 556 WINDOW AND GLAZED DOOR AREA 10 % OR LESS OF ABOVE-GRADE WALL AREA

<table>
<tr><th>Element</th><th colspan="4">Condition / Value</th></tr>
<tr><td>Skylights (U-factor)</td><td colspan="4">5.678</td></tr>
<tr><td>Slab or below-grade wall (R-value)</td><td colspan="4">R-0</td></tr>
<tr><td>Windows and Glass doors</td><td colspan="2">Solar Heat Gain Factor (SHGC)</td><td colspan="2">U-factor</td></tr>
<tr><td>PF < 0.25</td><td colspan="2">Any</td><td colspan="2">Any</td></tr>
<tr><td>0.25 ≤ PF < 0.50</td><td colspan="2">Any</td><td colspan="2">Any</td></tr>
<tr><td>PF ≥ 0.50</td><td colspan="2">Any</td><td colspan="2">Any</td></tr>
<tr><td>Roof assemblies (R-value)</td><td colspan="2">Insulation between framing</td><td colspan="2">Continuous insulation</td></tr>
<tr><td>All-wood joist/truss</td><td colspan="2">R-3.346</td><td colspan="2">R-2.289</td></tr>
<tr><td>Metal joist/truss</td><td colspan="2">R-3.346</td><td colspan="2">R-2.465</td></tr>
<tr><td>Concrete slab or deck</td><td colspan="2">NA</td><td colspan="2">R-2.289</td></tr>
<tr><td>Metal purlin with thermal block</td><td colspan="2">R-3.346</td><td colspan="2">R-2.465</td></tr>
<tr><td>Metal purlin without thermal block</td><td colspan="2">X</td><td colspan="2">R-2.465</td></tr>
<tr><td>Floors over outdoor air or unconditioned space (R-value)</td><td colspan="2">Insulation between framing</td><td colspan="2">Continuous insulation</td></tr>
<tr><td>All-wood joist/truss</td><td colspan="2">R-0</td><td colspan="2">R-0</td></tr>
<tr><td>Metal joist/truss</td><td colspan="2">R-1.937</td><td colspan="2">R-0.704</td></tr>
<tr><td>Concrete slab or deck</td><td colspan="2">NA</td><td colspan="2">R-0</td></tr>
<tr><td>Above-grade walls (R-value)</td><td>No framing</td><td colspan="2">Metal framing</td><td>Wood framing</td></tr>
<tr><td>Framed: R-value cavity</td><td>NA</td><td colspan="2">R-0</td><td>R-0</td></tr>
<tr><td>R-value continuous</td><td>NA</td><td colspan="2">R-0</td><td>R-0</td></tr>
<tr><td>Concrete masonry units (CMU) ≥ 200 mm: R-value cavity</td><td>NA</td><td colspan="2">R-0</td><td>R-0</td></tr>
<tr><td>R-value continuous</td><td>R-0</td><td colspan="2">R-0</td><td>R-0</td></tr>
<tr><td>Other masonry walls:
R-value cavity</td><td>NA</td><td colspan="2">R-0</td><td>R-0</td></tr>
<tr><td>R-value continuous</td><td>R-0</td><td colspan="2">R-0</td><td>R-0</td></tr>
</table>

TABLE 6.2.2(6) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 10 % BUT NOT GREATER THAN 25% OF ABOVE-GRADE WALL AREA

<table>
<tr><th>Element</th><th colspan="3">Condition / Value</th></tr>
<tr><td>Skylights (U-factor)</td><td colspan="3">5.678</td></tr>
<tr><td>Slab or below-grade wall (R-value)</td><td colspan="3">R-0</td></tr>
<tr><td>Windows and Glass doors</td><td colspan="2">Solar Heat Gain Factor (SHGC)</td><td>U-factor</td></tr>
<tr><td>PF < 0.25</td><td colspan="2">0.5</td><td>Any</td></tr>
<tr><td>0.25 ≤ PF < 0.50</td><td colspan="2">0.6</td><td>Any</td></tr>
<tr><td>PF ≥ 0.50</td><td colspan="2">0.7</td><td>Any</td></tr>
<tr><td>Roof assemblies (R-value)</td><td colspan="2">Insulation between framing</td><td>Continuous insulation</td></tr>
<tr><td>All-wood joist/truss</td><td colspan="2">R-3.346</td><td>R-2.289</td></tr>
<tr><td>Metal joist/truss</td><td colspan="2">R-3.346</td><td>R-2.465</td></tr>
<tr><td>Concrete slab or deck</td><td colspan="2">NA</td><td>R-2.289</td></tr>
<tr><td>Metal purlin with thermal block</td><td colspan="2">R-3.346</td><td>R-2.465</td></tr>
<tr><td>Metal purlin without thermal block</td><td colspan="2">X</td><td>R-2.465</td></tr>
<tr><td>Floors over outdoor air or unconditioned space (R-value)</td><td colspan="2">Insulation between framing</td><td>Continuous insulation</td></tr>
<tr><td>All-wood joist/truss</td><td colspan="2">R-0</td><td>R-0</td></tr>
<tr><td>Metal joist/truss</td><td colspan="2">R-1.937</td><td>R-0.704</td></tr>
<tr><td>Concrete slab or deck</td><td colspan="2">NA</td><td>R-0</td></tr>
<tr><td>Above-grade walls (R-value)</td><td>No framing</td><td>Metal framing</td><td>Wood framing</td></tr>
<tr><td>Framed: R-value cavity</td><td>NA</td><td>R-0</td><td>R-0</td></tr>
<tr><td>R-value continuous</td><td>NA</td><td>R-0</td><td>R-0</td></tr>
<tr><td>Concrete masonry units (CMU) ≥ 200 mm:</td><td></td><td></td><td></td></tr>
<tr><td>R-value cavity</td><td>NA</td><td>R-0</td><td>R-0</td></tr>
<tr><td>R-value continuous</td><td>R-0</td><td>R-0</td><td>R-0</td></tr>
<tr><td>Other masonry walls:</td><td></td><td></td><td></td></tr>
<tr><td>R-value cavity</td><td>NA</td><td>R-0</td><td>R-0</td></tr>
<tr><td>R-value continuous</td><td>R-0</td><td>R-0</td><td>R-0</td></tr>
</table>

TABLE 6.2.2(6) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 25 % BUT NOT GREATER THAN 40% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	5.678		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**	***U*-factor**	
PF < 0.25	0.4	3.975	
0.25 ≤ PF < 0.50	0.5	3.975	
PF ≥ 0.50	0.6	3.975	
Roof assemblies (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	R-3.346	R-2.289	
Metal joist/truss	R-3.346	R-2.465	
Concrete slab or deck	NA	R-2.289	
Metal purlin with thermal block	R-3.346	R-2.465	
Metal purlin without thermal block	X	R-2.465	
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	R-0	R-0	
Metal joist/truss	R-1.937	R-0.704	
Concrete slab or deck	NA	R-0	
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-0	R-0
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0

TABLE 6.2.2(6) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 40 % BUT NOT GREATER THAN 50% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	5.678		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.4		3.975
0.25 ≤ PF < 0.50	0.5		3.975
PF ≥ 0.50	0.6		3.975
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.289
Metal joist/truss	R-3.346		R-2.465
Concrete slab or deck	NA		R-2.289
Metal purlin with thermal block	R-3.346		R-2.465
Metal purlin without thermal block	X		R-2.465
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-0		R-0
Metal joist/truss	R-1.937		R-0.704
Concrete slab or deck	NA		R-0
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.233	R-1.233
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0

DD(F) = DD(C)*1.8; 1 W/m^2 · K = 0.1761 BTU/(hr.ft^2 · °F); 1 m^2 · K/W = 5.678 hr.ft^2 · °F/BTU

TABLE 6.2.2(7)

BUILDING ENVELOPE REQUIREMENTS FOR 556 ≤ HDD/CDD (°C) < 833
WINDOW AND GLAZED DOOR AREA 10 % OR LESS OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	5.678		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	Any		Any
0.25 ≤ PF < 0.50	Any		Any
PF ≥ 0.50	Any		Any
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-1.937		R-1.585
Metal joist/truss	R-1.937		R-1.761
Concrete slab or deck	NA		R-1.585
Metal purlin with thermal block	R-2.289		R-1.761
Metal purlin without thermal block	R-4.403		R-1.761
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-1.937		R-0.704
Metal joist/truss	R-1.937		R-0.704
Concrete slab or deck	NA		R-0.352
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-0	R-0
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0

TABLE 6.2.2(7) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 10 % BUT NOT GREATER THAN 25% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	5.678		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.6		Any
0.25 ≤ PF < 0.50	0.7		Any
PF ≥ 0.50	Any		Any
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.113
Metal joist/truss	R-3.346		R-2.289
Concrete slab or deck	NA		R-2.113
Metal purlin with thermal block	R-3.346		R-2.289
Metal purlin without thermal block	R-5.284		R-2.289
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-1.937		R-0.704
Metal joist/truss	R-1.937		R-0.704
Concrete slab or deck	NA		R-0.352
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-0	R-0
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0

TABLE 6.2.2(7) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 25 % BUT NOT GREATER THAN 40% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	5.678		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.5		3.975
0.25 ≤ PF < 0.50	0.6		3.975
PF ≥ 0.50	0.7		3.975
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.113
Metal joist/truss	R-3.346		R-2.289
Concrete slab or deck	NA		R-2.113
Metal purlin with thermal block	R-3.346		R-2.289
Metal purlin without thermal block	R-5.284		R-2.289
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-1.937		R-0.704
Metal joist/truss	R-1.937		R-0.704
Concrete slab or deck	NA		R-0.352
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-19.7	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0

TABLE 6.2.2(7) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 40 % BUT NOT GREATER THAN 50% OF ABOVE-GRADE WALL AREA

<table>
<tr><th>Element</th><th colspan="3">Condition / Value</th></tr>
<tr><td>Skylights (U-factor)</td><td colspan="3">5.678</td></tr>
<tr><td>Slab or below-grade wall (R-value)</td><td colspan="3">R-0</td></tr>
<tr><td>Windows and Glass doors</td><td colspan="2">Solar Heat Gain Factor (SHGC)</td><td>U-factor</td></tr>
<tr><td>PF < 0.25</td><td colspan="2">0.4</td><td>3.975</td></tr>
<tr><td>0.25 ≤ PF < 0.50</td><td colspan="2">0.5</td><td>3.975</td></tr>
<tr><td>PF ≥ 0.50</td><td colspan="2">0.7</td><td>3.975</td></tr>
<tr><td>Roof assemblies (R-value)</td><td colspan="2">Insulation between framing</td><td>Continuous insulation</td></tr>
<tr><td>All-wood joist/truss</td><td colspan="2">R-3.346</td><td>R-2.113</td></tr>
<tr><td>Metal joist/truss</td><td colspan="2">R-3.346</td><td>R-2.289</td></tr>
<tr><td>Concrete slab or deck</td><td colspan="2">NA</td><td>R-2.113</td></tr>
<tr><td>Metal purlin with thermal block</td><td colspan="2">R-3.346</td><td>R-2.289</td></tr>
<tr><td>Metal purlin without thermal block</td><td colspan="2">R-5.284</td><td>R-2.289</td></tr>
<tr><td>Floors over outdoor air or unconditioned space (R-value)</td><td colspan="2">Insulation between framing</td><td>Continuous insulation</td></tr>
<tr><td>All-wood joist/truss</td><td colspan="2">R-1.937</td><td>R-0.704</td></tr>
<tr><td>Metal joist/truss</td><td colspan="2">R-1.937</td><td>R-0.704</td></tr>
<tr><td>Concrete slab or deck</td><td colspan="2">NA</td><td>R-0.352</td></tr>
<tr><td>Above-grade walls (R-value)</td><td>No framing</td><td>Metal framing</td><td>Wood framing</td></tr>
<tr><td>Framed: R-value cavity</td><td>NA</td><td>R-1.937</td><td>R-1.937</td></tr>
<tr><td>R-value continuous</td><td>NA</td><td>R-0</td><td>R-0</td></tr>
<tr><td>Concrete masonry units (CMU) ≥ 200 mm:</td><td></td><td></td><td></td></tr>
<tr><td>R-value cavity</td><td>NA</td><td>R-0</td><td>R-0</td></tr>
<tr><td>R-value continuous</td><td>R-0</td><td>R-0</td><td>R-0</td></tr>
<tr><td>Other masonry walls:</td><td></td><td></td><td></td></tr>
<tr><td>R-value cavity</td><td>NA</td><td>R-0</td><td>R-0</td></tr>
<tr><td>R-value continuous</td><td>R-0</td><td>R-0</td><td>R-0</td></tr>
</table>

DD(F) = DD(C)*1.8; 1 $W/m^2 \cdot K$ = 0.1761 $BTU/(hr.ft^2 \cdot °F)$; 1 $m^2 \cdot K/W$ = 5.678 $hr.ft^2 \cdot °F/BTU$

TABLE 6.2.2(8)
BUILDING ENVELOPE REQUIREMENTS FOR 833 ≤ HDD/CDD (^{o}C) 833 < 1111
WINDOW AND GLAZED DOOR AREA 10 % OR LESS
OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	5.678		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	Any		Any
0.25 ≤ PF < 0.50	Any		Any
PF ≥ 0.50	Any		Any
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-2.289		R-1.937
Metal joist/truss	R-2.289		R-1.113
Concrete slab or deck	NA		R-1.937
Metal purlin with thermal block	R-3.346		R-1.113
Metal purlin without thermal block	R-5.284		R-1.113
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-1.937		R-0.704
Metal joist/truss	R-1.937		R-0.704
Concrete slab or deck	NA		R-0.528
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-0	R-0
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0

TABLE 6.2.2(8) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 10 % BUT NOT GREATER THAN 25% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	5.678		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**	***U*-factor**	
PF < 0.25	0.6	Any	
0.25 ≤ PF < 0.50	0.7	Any	
PF ≥ 0.50	Any	Any	
Roof assemblies (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	R-3.346	R-2.113	
Metal joist/truss	R-3.346	R-2.289	
Concrete slab or deck	NA	R-2.113	
Metal purlin with thermal block	R-3.346	R-2.289	
Metal purlin without thermal block	R-5.284	R-2.289	
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	R-1.937	R-0.704	
Metal joist/truss	R-1.937	R-0.704	
Concrete slab or deck	NA	R-0.528	
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0

TABLE 6.2.2(8) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 25 % BUT NOT GREATER THAN 40% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	5.678		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.5		3.975
0.25 ≤ PF < 0.50	0.6		3.975
PF ≥ 0.50	0.7		3.975
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.113
Metal joist/truss	R-3.346		R-2.289
Concrete slab or deck	NA		R-2.113
Metal purlin with thermal block	R-3.346		R-2.289
Metal purlin without thermal block	R-5.284		R-2.289
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-1.937		R-0.704
Metal joist/truss	R-1.937		R-0.704
Concrete slab or deck	NA		R-0.528
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(8) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 40 % BUT NOT GREATER THAN 50% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	5.678		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.4		3.975
0.25 ≤ PF < 0.50	0.5		3.975
PF ≥ 0.50	0.7		3.975
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.113
Metal joist/truss	R-3.346		R-2.289
Concrete slab or deck	NA		R-2.113
Metal purlin with thermal block	R-3.346		R-2.289
Metal purlin without thermal block	R-5.284		R-2.289
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-1.937		R-0.704
Metal joist/truss	R-1.937		R-0.704
Concrete slab or deck	NA		R-0.528
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

DD(F) = DD(C)*1.8; 1 $W/m^2 \cdot K$ = 0.1761 $BTU/(hr.ft^2 \cdot °F)$; 1 $m^2 \cdot K/W$ = 5.678 $hr.ft^2 \cdot °F/BTU$

TABLE 6.2.2(9)
BUILDING ENVELOPE REQUIREMENTS FOR 111 ≤ HDD/CDD (°C) 1111 < 1389
WINDOW AND GLAZED DOOR AREA 10 % OR LESS OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	5.678		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**	***U*-factor**	
PF < 0.25	Any	Any	
0.25 ≤ PF < 0.50	Any	Any	
PF ≥ 0.50	Any	Any	
Roof assemblies (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	R-3.346	R-2.465	
Metal joist/truss	R-3.346	R-2.642	
Concrete slab or deck	NA	R-2.465	
Metal purlin with thermal block	R-4.403	R-2.642	
Metal purlin without thermal block	X	R-2.642	
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	R-1.937	R-0.881	
Metal joist/truss	R-1.937	R-1.057	
Concrete slab or deck	NA	R-0.881	
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0

TABLE 6.2.2(9) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 10 % BUT NOT GREATER THAN 25% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	5.678		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.6		Any
0.25 ≤ PF < 0.50	0.7		Any
PF ≥ 0.50	Any		Any
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.818
Metal joist/truss	R-4.403		R-2.994
Concrete slab or deck	NA		R-2.818
Metal purlin with thermal block	R-4.403		R-2.994
Metal purlin without thermal block	X		R-2.994
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-1.937		R-0.881
Metal joist/truss	R-1.937		R-1.057
Concrete slab or deck	NA		R-0.881
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(9) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 25 % BUT NOT GREATER THAN 40% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	5.678		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**	**U-factor**	
PF < 0.25	0.5	3.975	
0.25 ≤ PF < 0.50	0.6	3.975	
PF ≥ 0.50	0.7	3.975	
Roof assemblies (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	R-3.346	R-2.818	
Metal joist/truss	R-4.403	R-2.994	
Concrete slab or deck	NA	R-2.818	
Metal purlin with thermal block	R-4.403	R-2.994	
Metal purlin without thermal block	X	R-2.994	
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	R-1.937	R-0.881	
Metal joist/truss	R-1.937	R-1.057	
Concrete slab or deck	NA	R-0.881	
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(9) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 40 % BUT NOT GREATER THAN 50% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	5.678		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.4		3.975
0.25 ≤ PF < 0.50	0.5		3.975
PF ≥ 0.50	0.7		3.975
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.818
Metal joist/truss	R-4.403		R-2.994
Concrete slab or deck	NA		R-2.818
Metal purlin with thermal block	R-4.403		R-2.994
Metal purlin without thermal block	X		R-2.994
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-1.937		R-0.881
Metal joist/truss	R-1.937		R-1.057
Concrete slab or deck	NA		R-0.881
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

DD(F)=DD(C)*1.8; 1 $W/m^2 \cdot K$ = 0.1761 $BTU/(hr.ft^2 \cdot °F)$; 1 $m^2 \cdot K/W$ = 5.678 $hr.ft^2 \cdot °F/BTU$

TABLE 6.2.2(10)
BUILDING ENVELOPE REQUIREMENTS FOR 1389 ≤ HDD/CDD (°C) < 1666
WINDOW AND GLAZED DOOR AREA 10 % OR LESS
OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	Any		Any
0.25 ≤ PF < 0.50	Any		Any
PF ≥ 0.50	Any		Any
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-1.937		R-1.761
Metal joist/truss	R-2.289		R-1.937
Concrete slab or deck	NA		R-1.761
Metal purlin with thermal block	R-3.346		R-1.937
Metal purlin without thermal block	R-4.403		R-1.937
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-1.937		R-1.233
Metal joist/truss	R-1.937		R-1.409
Concrete slab or deck	NA		R-1.233
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0

TABLE 6.2.2(10) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 10 % BUT NOT GREATER THAN 25% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.7		Any
0.25 ≤ PF < 0.50	Any		Any
PF ≥ 0.50	Any		Any
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.346
Metal joist/truss	R-4.403		R-3.522
Concrete slab or deck	NA		R-3.346
Metal purlin with thermal block	R-5.284		R-3.522
Metal purlin without thermal block	X		R-3.522
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-1.937		R-1.233
Metal joist/truss	R-1.937		R-1.409
Concrete slab or deck	NA		R-1.233
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(10) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 25 % BUT NOT GREATER THAN 40% OF ABOVE-GRADE WALL AREA

<table>
<tr><th>Element</th><th colspan="3">Condition / Value</th></tr>
<tr><td>Skylights (U-factor)</td><td colspan="3">4.542</td></tr>
<tr><td>Slab or below-grade wall (R-value)</td><td colspan="3">R-0</td></tr>
<tr><td>Windows and Glass doors</td><td colspan="2">Solar Heat Gain Factor (SHGC)</td><td>U-factor</td></tr>
<tr><td>PF < 0.25
0.25 ≤ PF < 0.50
PF ≥ 0.50</td><td colspan="2">0.5
0.6
0.7</td><td>3.975
3.975
3.975</td></tr>
<tr><td>Roof assemblies (R-value)</td><td colspan="2">Insulation between framing</td><td>Continuous insulation</td></tr>
<tr><td>All-wood joist/truss
Metal joist/truss
Concrete slab or deck
Metal purlin with thermal block
Metal purlin without thermal block</td><td colspan="2">R-4.403
R-4.403
NA
R-5.284
X</td><td>R-19
R-20
R-19
R-20
R-20</td></tr>
<tr><td>Floors over outdoor air or unconditioned space (R-value)</td><td colspan="2">Insulation between framing</td><td>Continuous insulation</td></tr>
<tr><td>All-wood joist/truss
Metal joist/truss
Concrete slab or deck</td><td colspan="2">R-1.937
R-1.937
NA</td><td>R-1.233
R-1.409
R-1.233</td></tr>
<tr><td>Above-grade walls (R-value)</td><td>No framing</td><td>Metal framing</td><td>Wood framing</td></tr>
<tr><td>Framed: R-value cavity
R-value continuous
Concrete masonry units (CMU) ≥ 200 mm:
R-value cavity
R-value continuous
Other masonry walls:
R-value cavity
R-value continuous</td><td>NA
NA

NA
R-0

NA
R-0.881</td><td>R-1.937
R-0

R-0
R-0

R-1.937
R-0</td><td>R-1.937
R-0

R-0
R-0

R-1.937
R-0</td></tr>
</table>

TABLE 6.2.2(10) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 40 % BUT NOT GREATER THAN 50% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	1		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.4		3.975
0.25 ≤ PF < 0.50	0.5		3.975
PF ≥ 0.50	0.7		3.975
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.346
Metal joist/truss	R-4.403		R-3.522
Concrete slab or deck	NA		R-3.346
Metal purlin with thermal block	R-5.284		R-3.522
Metal purlin without thermal block	X		R-3.522
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-1.937		R-1.233
Metal joist/truss	R-1.937		R-1.409
Concrete slab or deck	NA		R-1.233
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

DD(F)=DD(C)*1.8; 1 $W/m^2 \cdot K$ = 0.1761 $BTU/(hr.ft^2 \cdot °F)$; 1 $m^2 \cdot K/W$ = 5.678 $hr.ft^2 \cdot °F/BTU$

TABLE 6.2.2(11)
BUILDING ENVELOPE REQUIREMENTS FOR 1666 ≤ HDD/CDD (°C) 1666 < 1944
WINDOW AND GLAZED DOOR AREA 10 % OR LESS
OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**	**_U_-factor**	
PF < 0.25	Any	Any	
0.25 ≤ PF < 0.50	Any	Any	
PF ≥ 0.50	Any	Any	
Roof assemblies (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	R-3.346	R-2.465	
Metal joist/truss	R-3.346	R-2.642	
Concrete slab or deck	NA	R-2.465	
Metal purlin with thermal block	R-4.403	R-2.642	
Metal purlin without thermal block	X	R-2.642	
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	R-1.937	R-1.409	
Metal joist/truss	R-1.937	R-1.585	
Concrete slab or deck	NA	R-1.409	
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(11) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 10 % BUT NOT GREATER THAN 25% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF ≥) 0.25	0.5		3.975
0.25 ≤ PF < 0.50	0.6		3.975
PF ≥ 0.50	0.7		3.975
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.346
Metal joist/truss	R-4.403		R-3.522
Concrete slab or deck	NA		R-3.346
Metal purlin with thermal block	R-5.284		R-3.522
Metal purlin without thermal block	X		R-3.522
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-1.937		R-1.409
Metal joist/truss	R-1.937		R-1.585
Concrete slab or deck	NA		R-1.409
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(11) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 25 % BUT NOT GREATER THAN 40% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.4		3.975
0.25 ≤ PF < 0.50	0.5		3.975
PF ≥ 0.50	0.6		3.975
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.346
Metal joist/truss	R-4.403		R-3.522
Concrete slab or deck	NA		R-3.346
Metal purlin with thermal block	R-5.284		R-3.522
Metal purlin without thermal block	X		R-3.522
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-1.937		R-1.409
Metal joist/truss	R-1.937		R-1.585
Concrete slab or deck	NA		R-1.409
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(11) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 40 % BUT NOT GREATER THAN 50% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.3		3.975
0.25 ≤ PF < 0.50	0.4		3.975
PF ≥ 0.50	0.5		3.975
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.346
Metal joist/truss	R-4.403		R-3.522
Concrete slab or deck	NA		R-3.346
Metal purlin with thermal block	R-5.284		R-3.522
Metal purlin without thermal block	R-6.692		R-3.522
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-1.937		R-1.409
Metal joist/truss	R-1.937		R-1.585
Concrete slab or deck	NA		R-1.409
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

DD(F)=DD(C)*1.8; 1 W/m^2 · K = 0.1761 BTU/(hr.ft^2 · °F); 1 m^2 · K/W = 5.678 hr.ft^2 · °F/BTU

TABLE 6.2.2(12)
BUILDING ENVELOPE REQUIREMENTS FOR 1944 ≤ HDD/CDD (°C) < 2222
WINDOW AND GLAZED DOOR AREA 10 % OR LESS
OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**	**_U_-factor**	
PF < 0.25	Any	Any	
0.25 ≤ PF < 0.50	Any	Any	
PF ≥ 0.50	Any	Any	
Roof assemblies (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	R-3.346	R-2.465	
Metal joist/truss	R-3.346	R-2.642	
Concrete slab or deck	NA	R-2.465	
Metal purlin with thermal block	R-4.403	R-2.642	
Metal purlin without thermal block	X	R-2.642	
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	R-1.937	R-1.585	
Metal joist/truss	R-1.937	R-1.761	
Concrete slab or deck	NA	R-1.585	
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(12) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 10 % BUT NOT GREATER THAN 25% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.5		3.975
0.25 ≤ PF < 0.50	0.6		3.975
PF ≥ 0.50	0.7		3.975
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.346
Metal joist/truss	R-4.403		R-3.522
Concrete slab or deck	NA		R-3.346
Metal purlin with thermal block	R-5.284		R-3.522
Metal purlin without thermal block	X		R-3.522
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-1.937		R-1.585
Metal joist/truss	R-1.937		R-1.761
Concrete slab or deck	NA		R-1.585
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-2.289	R-1.937
R-value continuous	R-1.057	R-0	R-0

TABLE 6.2.2(12) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 25 % BUT NOT GREATER THAN 40% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.4		2.839
0.25 ≤ PF < 0.50	0.5		2.839
PF ≥ 0.50	0.6		2.839
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.346
Metal joist/truss	R-4.403		R-3.522
Concrete slab or deck	NA		R-3.346
Metal purlin with thermal block	R-5.284		R-3.522
Metal purlin without thermal block	X		R-3.522
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-1.937		R-1.585
Metal joist/truss	R-1.937		R-1.761
Concrete slab or deck	NA		R-1.585
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-2.289	R-1.937
R-value continuous	R-1.057	R-0	R-0

TABLE 6.2.2(12) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 40 % BUT NOT GREATER THAN 50% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**	***U*-factor**	
PF < 0.25	0.3	2.839	
0.25 ≤ PF < 0.50	0.4	2.839	
PF ≥ 0.50	0.5	2.839	
Roof assemblies (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	R-4.403	R-3.346	
Metal joist/truss	R-4.403	R-3.522	
Concrete slab or deck	NA	R-3.346	
Metal purlin with thermal block	R-5.284	R-3.522	
Metal purlin without thermal block	R-6.692	R-3.522	
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	R-1.937	R-1.585	
Metal joist/truss	R-1.937	R-1.761	
Concrete slab or deck	NA	R-1.585	
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-2.289	R-1.937
R-value continuous	R-1.057	R-0	R-0

DD(F)=DD(C)*1.8; 1 $W/m^2 \cdot K$ = 0.1761 $BTU/(hr.ft^2 \cdot °F)$; 1 $m^2 \cdot K/W$ = 5.678 $hr.ft^2 \cdot °F/BTU$

TABLE 6.2.2(13)
BUILDING ENVELOPE REQUIREMENTS FOR 2222 ≤ HDD/CDD (^{o}C) < 2500
WINDOW AND GLAZED DOOR AREA 10 % OR LESS
OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	Any		Any
0.25 ≤ PF < 0.50	Any		Any
PF ≥ 0.50	Any		Any
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.289
Metal joist/truss	R-3.346		R-2.465
Concrete slab or deck	NA		R-2.289
Metal purlin with thermal block	R-3.346		R-2.465
Metal purlin without thermal block	X		R-2.465
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-2.289		R-2.113
Metal joist/truss	R-2.289		R-2.113
Concrete slab or deck	NA		R-2.113
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(13) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 10 % BUT NOT GREATER THAN 25% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	Any		3.975
0.25 ≤ PF < 0.50	Any		3.975
PF ≥ 0.50	Any		3.975
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.818
Metal joist/truss	R-4.403		R-2.994
Concrete slab or deck	NA		R-2.818
Metal purlin with thermal block	R-4.403		R-2.994
Metal purlin without thermal block	X		R-2.994
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-2.898		R-2.113
Metal joist/truss	R-2.898		R-2.113
Concrete slab or deck	NA		R-2.113
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(13) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 25 % BUT NOT GREATER THAN 40% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.6		3.975
0.25 ≤ PF < 0.50	0.7		3.975
PF ≥ 0.50	Any		3.975
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.346
Metal joist/truss	R-4.403		R-3.522
Concrete slab or deck	NA		R-3.346
Metal purlin with thermal block	R-5.284		R-3.522
Metal purlin without thermal block	X		R-3.522
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-2.289		R-2.113
Metal joist/truss	R-2.289		R-2.113
Concrete slab or deck	NA		R-2.113
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(13) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 40 % BUT NOT GREATER THAN 50% OF ABOVE-GRADE WALL AREA

<table>
<tr><th>Element</th><th colspan="3">Condition / Value</th></tr>
<tr><td>Skylights (U-factor)</td><td colspan="3">4.542</td></tr>
<tr><td>Slab or below-grade wall (R-value)</td><td colspan="3">R-0</td></tr>
<tr><td>Windows and Glass doors</td><td colspan="2">Solar Heat Gain Factor (SHGC)</td><td>U-factor</td></tr>
<tr><td>PF < 0.25</td><td colspan="2">0.5</td><td>2.839</td></tr>
<tr><td>0.25 ≤ PF < 0.50</td><td colspan="2">0.7</td><td>2.839</td></tr>
<tr><td>PF ≥ 0.50</td><td colspan="2">0.8</td><td>2.839</td></tr>
<tr><td>Roof assemblies (R-value)</td><td colspan="2">Insulation between framing</td><td>Continuous insulation</td></tr>
<tr><td>All-wood joist/truss</td><td colspan="2">R-4.403</td><td>R-3.346</td></tr>
<tr><td>Metal joist/truss</td><td colspan="2">R-4.403</td><td>R-3.522</td></tr>
<tr><td>Concrete slab or deck</td><td colspan="2">NA</td><td>R-3.346</td></tr>
<tr><td>Metal purlin with thermal block</td><td colspan="2">R-5.284</td><td>R-3.522</td></tr>
<tr><td>Metal purlin without thermal block</td><td colspan="2">R-6.692</td><td>R-3.522</td></tr>
<tr><td>Floors over outdoor air or unconditioned space (R-value)</td><td colspan="2">Insulation between framing</td><td>Continuous insulation</td></tr>
<tr><td>All-wood joist/truss</td><td colspan="2">R-2.289</td><td>R-2.113</td></tr>
<tr><td>Metal joist/truss</td><td colspan="2">R-2.289</td><td>R-2.113</td></tr>
<tr><td>Concrete slab or deck</td><td colspan="2">NA</td><td>R-2.113</td></tr>
<tr><td>Above-grade walls (R-value)</td><td>No framing</td><td>Metal framing</td><td>Wood framing</td></tr>
<tr><td>Framed: R-value cavity</td><td>NA</td><td>R-2.289</td><td>R-2.289</td></tr>
<tr><td>R-value continuous</td><td>NA</td><td>R-1.937</td><td>R-0.881</td></tr>
<tr><td>Concrete masonry units (CMU) ≥ 200 mm:</td><td></td><td></td><td></td></tr>
<tr><td>R-value cavity</td><td>NA</td><td>R-1.937</td><td>R-1.937</td></tr>
<tr><td>R-value continuous</td><td>R-0.881</td><td>R-0</td><td>R-0</td></tr>
<tr><td>Other masonry walls:</td><td></td><td></td><td></td></tr>
<tr><td>R-value cavity</td><td>NA</td><td>R-1.937</td><td>R-1.937</td></tr>
<tr><td>R-value continuous</td><td>R-0.881</td><td>R-0</td><td>R-0</td></tr>
</table>

DD(F)=DD(C)*1.8; 1 W/m^2 · K = 0.1761 BTU/(hr.ft^2 · °F); 1 m^2 · K/W = 5.678 hr.ft^2 · °F/BTU

TABLE 6.2.2(14)
BUILDING ENVELOPE REQUIREMENTS FOR 2500 ≤ HDD/CDD (^oC) < 2778
WINDOW AND GLAZED DOOR AREA 10 % OR LESS
OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	Any		Any
0.25 ≤ PF < 0.50	Any		Any
PF ≥ 0.50	Any		Any
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.465
Metal joist/truss	R-3.346		R-2.642
Concrete slab or deck	NA		R-2.465
Metal purlin with thermal block	R-4.403		R-2.642
Metal purlin without thermal block	X		R-2.642
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.289
Metal joist/truss	R-3.346		R-2.289
Concrete slab or deck	NA		R-2.289
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-0	R-0
R-value continuous	R-0	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(14) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 10 % BUT NOT GREATER THAN 25% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.6		3.975
0.25 ≤ PF < 0.50	0.7		3.975
PF ≥ 0.50	Any		3.975
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.818
Metal joist/truss	R-4.403		R-2.994
Concrete slab or deck	NA		R-2.818
Metal purlin with thermal block	R-3.346		R-2.994
Metal purlin without thermal block	X		R-2.994
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.289
Metal joist/truss	R-3.346		R-2.289
Concrete slab or deck	NA		R-2.289
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-5	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(14) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 25 % BUT NOT GREATER THAN 40% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.5		3.407
0.25 ≤ PF < 0.50	0.6		3.407
PF ≥ 0.50	0.7		3.407
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.346
Metal joist/truss	R-4.403		R-3.522
Concrete slab or deck	NA		R-3.346
Metal purlin with thermal block	R-5.284		R-3.522
Metal purlin without thermal block	X		R-3.522
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.289
Metal joist/truss	R-3.346		R-2.289
Concrete slab or deck	NA		R-2.289
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(14) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 40 % BUT NOT GREATER THAN 50% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.5		2.271
0.25 ≤ PF < 0.50	0.6		2.271
PF ≥ 0.50	0.7		2.271
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.346
Metal joist/truss	R-4.403		R-3.522
Concrete slab or deck	NA		R-3.346
Metal purlin with thermal block	R-5.284		R-3.522
Metal purlin without thermal block	R-5.284		R-3.522
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.289
Metal joist/truss	R-3.346		R-2.289
Concrete slab or deck	NA		R-2.289
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-1.937
R-value continuous	NA	R-0.528	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

DD(F)=DD(C)*1.8; 1 $W/m^2 \cdot K$ = 0.1761 $BTU/(hr.ft^2 \cdot °F)$; 1 $m^2 \cdot K/W$ = 5.678 $hr.ft^2 \cdot °F/BTU$

TABLE 6.2.2(15)
BUILDING ENVELOPE REQUIREMENTS FOR 2778 ≤ HDD/CDD (°C) < 3055
WINDOW AND GLAZED DOOR AREA 10 % OR LESS
OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	Any		Any
0.25 ≤ PF < 0.50	Any		Any
PF ≥ 0.50	Any		Any
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.465
Metal joist/truss	R-3.346		R-2.642
Concrete slab or deck	NA		R-2.465
Metal purlin with thermal block	R-4.403		R-2.642
Metal purlin without thermal block	X		R-2.642
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.465
Metal joist/truss	R-3.346		R-2.465
Concrete slab or deck	NA		R-2.465
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(15) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 10 % BUT NOT GREATER THAN 25% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.6		3.975
0.25 ≤ PF < 0.50	0.7		3.975
PF ≥ 0.50	Any		3.975
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.818
Metal joist/truss	R-4.403		R-2.994
Concrete slab or deck	NA		R-2.818
Metal purlin with thermal block	R-4.403		R-2.994
Metal purlin without thermal block	X		R-2.994
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.465
Metal joist/truss	R-3.346		R-2.465
Concrete slab or deck	NA		R-2.465
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(15) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 25 % BUT NOT GREATER THAN 40% OF ABOVE-GRADE WALL AREA

Element	Condition / Value			
Skylights (*U*-factor)	4.542			
Slab or below-grade wall (*R*-value)	R-0			
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		**U-factor**	
PF < 0.25	0.6		3.407	
0.25 ≤ PF < 0.50	0.7		3.407	
PF ≥ 0.50	Any		3.407	
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**	
All-wood joist/truss	R-4.403		R-3.346	
Metal joist/truss	R-4.403		R-3.522	
Concrete slab or deck	NA		R-3.346	
Metal purlin with thermal block	R-5.284		R-3.522	
Metal purlin without thermal block	X		R-3.522	
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**	
All-wood joist/truss	R-3.346		R-2.465	
Metal joist/truss	R-3.346		R-2.465	
Concrete slab or deck	NA		R-2.465	
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**	
Framed: *R*-value cavity	NA	R-1.937	R-1.937	
R-value continuous	NA	R-0	R-0	
Concrete masonry units (CMU) ≥ 200 mm:				
R-value cavity	NA	R-1.937	R-1.937	
R-value continuous	R-0.881	R-0	R-0	
Other masonry walls:				
R-value cavity	NA	R-1.937	R-1.937	
R-value continuous	R-0.881	R-0	R-0	

TABLE 6.2.2(15) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 40 % BUT NOT GREATER THAN 50% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.5		2.271
0.25 ≤ PF < 0.50	0.6		2.271
PF ≥ 0.50	0.7		2.271
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.346
Metal joist/truss	R-4.403		R-3.522
Concrete slab or deck	NA		R-3.346
Metal purlin with thermal block	R-5.284		R-3.522
Metal purlin without thermal block	R-5.284		R-3.522
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.465
Metal joist/truss	R-3.346		R-2.465
Concrete slab or deck	NA		R-2.465
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.290	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

DD(F)=DD(C)*1.8; 1 $W/m^2 \cdot K$ = 0.1761 $BTU/(hr.ft^2 \cdot °F)$; 1 $m^2 \cdot K/W$ = 5.678 $hr.ft^2 \cdot °F/BTU$

TABLE 6.2.2(16)
BUILDING ENVELOPE REQUIREMENTS FOR 3055 ≤ HDD/CDD (°C) < 3333
WINDOW AND GLAZED DOOR AREA 10 % OR LESS
OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	Any		Any
0.25 ≤ PF < 0.50	Any		Any
PF ≥ 0.50	Any		Any
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.818
Metal joist/truss	R-4.403		R-2.994
Concrete slab or deck	NA		R-2.818
Metal purlin with thermal block	R-4.403		R-2.994
Metal purlin without thermal block	X		R-2.994
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.818
Metal joist/truss	R-3.346		R-2.818
Concrete slab or deck	NA		R-2.818
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(16) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 10 % BUT NOT GREATER THAN 25% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.6		3.407
0.25 ≤ PF < 0.50	0.7		3.407
PF ≥ 0.50	Any		3.407
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.346
Metal joist/truss	R-4.403		R-3.522
Concrete slab or deck	NA		R-3.346
Metal purlin with thermal block	R-5.284		R-3.522
Metal purlin without thermal block	X		R-3.522
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.818
Metal joist/truss	R-3.346		R-2.818
Concrete slab or deck	NA		R-2.818
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-1.937	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(16) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 25 % BUT NOT GREATER THAN 40% OF ABOVE-GRADE WALL AREA

<table>
<tr><th>Element</th><th colspan="3">Condition / Value</th></tr>
<tr><td>Skylights (U-factor)</td><td colspan="3">4.542</td></tr>
<tr><td>Slab or below-grade wall (R-value)</td><td colspan="3">R-8</td></tr>
<tr><td>Windows and Glass doors</td><td colspan="2">Solar Heat Gain Factor (SHGC)</td><td>U-factor</td></tr>
<tr><td>PF < 0.25</td><td colspan="2">0.5</td><td>2.839</td></tr>
<tr><td>0.25 ≤ PF < 0.50</td><td colspan="2">0.6</td><td>2.839</td></tr>
<tr><td>PF ≥ 0.50</td><td colspan="2">0.7</td><td>2.839</td></tr>
<tr><td>Roof assemblies (R-value)</td><td colspan="2">Insulation between framing</td><td>Continuous insulation</td></tr>
<tr><td>All-wood joist/truss</td><td colspan="2">R-5.284</td><td>R-4.051</td></tr>
<tr><td>Metal joist/truss</td><td colspan="2">R-5.284</td><td>R-4.227</td></tr>
<tr><td>Concrete slab or deck</td><td colspan="2">NA</td><td>R-4.051</td></tr>
<tr><td>Metal purlin with thermal block</td><td colspan="2">X</td><td>R-4.227</td></tr>
<tr><td>Metal purlin without thermal block</td><td colspan="2">X</td><td>R-4.227</td></tr>
<tr><td>Floors over outdoor air or unconditioned space (R-value)</td><td colspan="2">Insulation between framing</td><td>Continuous insulation</td></tr>
<tr><td>All-wood joist/truss</td><td colspan="2">R-3.346</td><td>R-2.818</td></tr>
<tr><td>Metal joist/truss</td><td colspan="2">R-3.346</td><td>R-2.818</td></tr>
<tr><td>Concrete slab or deck</td><td colspan="2">NA</td><td>R-2.818</td></tr>
<tr><td>Above-grade walls (R-value)</td><td>No framing</td><td>Metal framing</td><td>Wood framing</td></tr>
<tr><td>Framed: R-value cavity</td><td>NA</td><td>R-1.937</td><td>R-1.937</td></tr>
<tr><td>R-value continuous</td><td>NA</td><td>R-0</td><td>R-0</td></tr>
<tr><td>Concrete masonry units (CMU) ≥ 200 mm:</td><td></td><td></td><td></td></tr>
<tr><td>R-value cavity</td><td>NA</td><td>R-1.937</td><td>R-1.937</td></tr>
<tr><td>R-value continuous</td><td>R-0.881</td><td>R-0</td><td>R-0</td></tr>
<tr><td>Other masonry walls:</td><td></td><td></td><td></td></tr>
<tr><td>R-value cavity</td><td>NA</td><td>R-1.937</td><td>R-1.937</td></tr>
<tr><td>R-value continuous</td><td>R-0.881</td><td>R-0</td><td>R-0</td></tr>
</table>

TABLE 6.2.2(16) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 40 % BUT NOT GREATER THAN 50% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-8		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.4		2.271
0.25 ≤ PF < 0.50	0.5		2.271
PF ≥ 0.50	0.7		2.271
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-5.284		R-4.051
Metal joist/truss	R-5.284		R-4.227
Concrete slab or deck	NA		R-4.051
Metal purlin with thermal block	R-5.284		R-4.227
Metal purlin without thermal block	R-6.692		R-4.227
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.818
Metal joist/truss	R-3.346		R-2.818
Concrete slab or deck	NA		R-2.818
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

DD(F)=DD(C)*1.8; 1 $W/m^2 \cdot K$ = 0.1761 $BTU/(hr.ft^2 \cdot °F)$; 1 $m^2 \cdot K/W$ = 5.678 $hr.ft^2 \cdot °F/BTU$

TABLE 6.2.2(17)
BUILDING ENVELOPE REQUIREMENTS FOR 3333 ≤ HDD/CDD (^{o}C) < 3611
WINDOW AND GLAZED DOOR AREA 10 % OR LESS
OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	Any		3.975
0.25 ≤ PF < 0.50	Any		3.975
PF ≥ 0.50	Any		3.975
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.465
Metal joist/truss	R-3.346		R-2.642
Concrete slab or deck	NA		R-2.465
Metal purlin with thermal block	R-4.403		R-2.642
Metal purlin without thermal block	X		R-2.642
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.818
Metal joist/truss	R-4.403		R-2.994
Concrete slab or deck	NA		R-2.994
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(17) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 10 % BUT NOT GREATER THAN 25% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.6		3.407
0.25 ≤ PF < 0.50	0.7		3.407
PF ≥ 0.50	Any		3.407
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.346
Metal joist/truss	R-4.403		R-3.522
Concrete slab or deck	NA		R-3.346
Metal purlin with thermal block	R-5.284		R-3.522
Metal purlin without thermal block	X		R-3.522
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.818
Metal joist/truss	R-4.403		R-2.994
Concrete slab or deck	NA		R-2.994
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(17) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 25 % BUT NOT GREATER THAN 40% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-1.409		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.5		2.839
0.25 ≤ PF < 0.50	0.6		2.839
PF ≥ 0.50	0.7		2.839
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-5.284		R-4.051
Metal joist/truss	R-5.284		R-4.227
Concrete slab or deck	NA		R-4.051
Metal purlin with thermal block	X		R-4.227
Metal purlin without thermal block	X		R-4.227
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.818
Metal joist/truss	R-4.403		R-2.994
Concrete slab or deck	NA		R-2.994
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(17) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 40 % BUT NOT GREATER THAN 50% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-1.409		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.4		2.271
0.25 ≤ PF < 0.50	0.5		2.271
PF ≥ 0.50	0.7		2.271
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-5.284		R-4.051
Metal joist/truss	R-5.284		R-4.227
Concrete slab or deck	NA		R-4.051
Metal purlin with thermal block	R-5.284		R-4.227
Metal purlin without thermal block	R-6.692		R-4.227
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.818
Metal joist/truss	R-4.403		R-2.994
Concrete slab or deck	NA		R-2.994
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-1.937
R-value continuous	NA	R-0	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

DD(F)=DD(C)*1.8; 1 $W/m^2 \cdot K$ = 0.1761 $BTU/(hr.ft^2 \cdot °F)$; 1 $m^2 \cdot K/W$ = 5.678 $hr.ft^2 \cdot °F/BTU$

TABLE 6.2.2(18)
BUILDING ENVELOPE REQUIREMENTS FOR 3611 ≤ HDD/CDD (^{o}C) < 3889
WINDOW AND GLAZED DOOR AREA 10 % OR LESS
OF ABOVE-GRADE WALL AREA

Element	**Condition / Value**		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	Any		3.975
0.25 ≤ PF < 0.50	Any		3.975
PF ≥ 0.50	Any		3.975
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-3.346		R-2.994
Metal joist/truss	R-4.403		R-3.170
Concrete slab or deck	NA		R-2.994
Metal purlin with thermal block	R-5.284		R-3.170
Metal purlin without thermal block	X		R-3.170
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.170
Metal joist/truss	R-4.403		R-3.346
Concrete slab or deck	NA		R-3.346
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-1.937
R-value continuous	NA	R-3	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(18) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 10 % BUT NOT GREATER THAN 25% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-1.409		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.5		3.407
0.25 ≤ PF < 0.50	0.6		3.407
PF ≥ 0.50	0.7		3.407
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.346
Metal joist/truss	R-4.403		R-3.522
Concrete slab or deck	NA		R-3.346
Metal purlin with thermal block	R-5.284		R-3.522
Metal purlin without thermal block	X		R-3.522
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.170
Metal joist/truss	R-4.403		R-3.346
Concrete slab or deck	NA		R-3.346
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-1.937
R-value continuous	NA	R-3	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(18) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 25 % BUT NOT GREATER THAN 40% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-1.409		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.4		2.839
0.25 ≤ PF < 0.50	0.5		2.839
PF ≥ 0.50	0.6		2.839
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-5.284		R-4.051
Metal joist/truss	R-5.284		R-4.227
Concrete slab or deck	NA		R-4.051
Metal purlin with thermal block	X		R-4.227
Metal purlin without thermal block	X		R-4.227
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.170
Metal joist/truss	R-4.403		R-3.346
Concrete slab or deck	NA		R-3.346
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-1.937
R-value continuous	NA	R-3	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(18) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 40 % BUT NOT GREATER THAN 50% OF ABOVE-GRADE WALL AREA

Element	Condition /Value	
Skylights (*U*-factor)	4.542	
Slab or below-grade wall (*R*-value)	R-1.409	
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**	***U*-factor**
PF < 0.25	0.4	2.271
0.25 ≤ PF < 0.50	0.5	2.271
PF ≥ 0.50	0.6	2.271
Roof assemblies (*R*-value)	**Insulation between framing**	**Continuous insulation**
All-wood joist/truss	R-5.284	R-4.051
Metal joist/truss	R-5.284	R-4.227
Concrete slab or deck	NA	R-4.051
Metal purlin with thermal block	R-6.692	R-4.227
Metal purlin without thermal block	R-6.692	R-4.227
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**	**Continuous insulation**
All-wood joist/truss	R-4.403	R-3.170
Metal joist/truss	R-4.403	R-3.346
Concrete slab or deck	NA	R-3.346

Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-1.937
R-value continuous	NA	R-3	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

DD(F)=DD(C)*1.8; 1 $W/m^2 \cdot K$ = 0.1761 $BTU/(hr.ft^2 \cdot °F)$; 1 $m^2 \cdot K/W$ = 5.678 $hr.ft^2 \cdot °F/BTU$

TABLE 6.2.2(19)
BUILDING ENVELOPE REQUIREMENTS FOR 3889 ≤ Hdd/Cdd (^oC) < 4166
WINDOW AND GLAZED DOOR AREA 10 % OR LESS
OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	4.542		
Slab or below-grade wall (*R*-value)	R-0		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	Any		3.975
0.25 ≤ PF < 0.50	Any		3.975
PF ≥ 0.50	Any		3.975
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.346
Metal joist/truss	R-4.403		R-3.522
Concrete slab or deck	NA		R-3.346
Metal purlin with thermal block	R-5.284		R-3.522
Metal purlin without thermal block	X		R-3.522
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.875
Metal joist/truss	R-5.284		R-4.051
Concrete slab or deck	NA		R-3.875
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-1.937
R-value continuous	NA	R-0.528	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(19) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 10 % BUT NOT GREATER THAN 25% OF ABOVE-GRADE WALL AREA

Element	Condition /Value		
Skylights (*U*-factor)	3.407		
Slab or below-grade wall (*R*-value)	R-1.409		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.5		2.839
0.25 ≤ PF < 0.50	0.6		2.839
PF ≥ 0.50	0.7		2.839
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.346
Metal joist/truss	R-4.403		R-3.522
Concrete slab or deck	NA		R-3.346
Metal purlin with thermal block	R-5.284		R-3.522
Metal purlin without thermal block	X		R-3.522
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.875
Metal joist/truss	R-5.284		R-4.051
Concrete slab or deck	NA		R-3.875
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-1.937
R-value continuous	NA	R-0.528	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(19) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 25 % BUT NOT GREATER THAN 40% OF ABOVE-GRADE WALL AREA

Element	Condition /Value		
Skylights (*U*-factor)	3.407		
Slab or below-grade wall (*R*-value)	R-1.409		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.5		2.271
0.25 ≤ PF < 0.50	0.6		2.271
PF ≥ 0.50	0.7		2.271
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-5.284		R-4.051
Metal joist/truss	R-5.284		R-4.227
Concrete slab or deck	NA		R-4.051
Metal purlin with thermal block	X		R-4.227
Metal purlin without thermal block	X		R-4.227
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.875
Metal joist/truss	R-5.284		R-4.051
Concrete slab or deck	NA		R-3.875
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-1.937
R-value continuous	NA	R-0.528	R-0
Concrete masonry units(CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-2.289	R-1.937
R-value continuous	R-1.057	R-0	R-0

TABLE 6.2.2(19) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 40 % BUT NOT GREATER THAN 50% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	3.407		
Slab or below-grade wall (*R*-value)	R-1.409		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.4		2.271
0.25 ≤ PF < 0.50	0.5		2.271
PF ≥ 0.50	0.7		2.271
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-5.284		R-4.051
Metal joist/truss	R-5.284		R-4.227
Concrete slab or deck	NA		R-4.051
Metal purlin with thermal block	R-6.692		R-4.277
Metal purlin without thermal block	X		R-4.277
Floors over outdoor air or unconditioned space(*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.875
Metal joist/truss	R-5.284		R-4.051
Concrete slab or deck	NA		R-3.875
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-2.289
R-value continuous	NA	R-1.233	R-0.704
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-2.289	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-2.89	R-1.937
R-value continuous	R-1.057	R-0.528	R-0

DD(F)=DD(C)*1.8; 1 W/$m^2 \cdot$ K = 0.1761 BTU/(hr.$ft^2 \cdot$ °F); 1 $m^2 \cdot$ K/W = 5.678 hr.$ft^2 \cdot$ °F/BTU

TABLE 6.2.2(20)
BUILDING ENVELOPE REQUIREMENTS FOR 4166 ≤ HDD/CDD (^{o}C) < 4444
WINDOW AND GLAZED DOOR AREA 10 % OR LESS
OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	3.407		
Slab or below-grade wall (*R*-value)	R-1.409		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.7		1.057
0.25 ≤ PF < 0.50	Any		1.057
PF ≥ 0.50	Any		1.057
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.346
Metal joist/truss	R-4.403		R-3.522
Concrete slab or deck	NA		R-3.346
Metal purlin with thermal block	R-5.284		R-3.522
Metal purlin without thermal block	X		R-3.522
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.875
Metal joist/truss	R-5.284		R-4.051
Concrete slab or deck	NA		R-3.875
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-1.937
R-value continuous	NA	R-0.528	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0

TABLE 6.2.2(20) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 10 % BUT NOT GREATER THAN 25% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	3.407		
Slab or below-grade wall (*R*-value)	R-1.409		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.7		2.839
0.25 ≤ PF < 0.50	Any		2.839
PF ≥ 0.50	Any		2.839
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-5.284		R-4.051
Metal joist/truss	R-5.284		R-4.227
Concrete slab or deck	NA		R-4.051
Metal purlin with thermal block	X		R-4.227
Metal purlin without thermal block	X		R-4.227
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.875
Metal joist/truss	R-5.284		R-4.051
Concrete slab or deck	NA		R-3.875
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-1.937
R-value continuous	NA	R-0.528	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-1.937	R-1.937
R-value continuous	R-0.881	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-2.289	R-1.937
R-value continuous	R-1.585	R-0.528	R-0

TABLE 6.2.2(20) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 25 % BUT NOT GREATER THAN 40% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	3.407		
Slab or below-grade wall (*R*-value)	R-1.409		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.5		2.271
0.25 ≤ PF < 0.50	0.6		2.271
PF ≥ 0.50	0.7		2.271
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-5.284		R-4.051
Metal joist/truss	R-5.284		R-4.227
Concrete slab or deck	NA		R-4.051
Metal purlin with thermal block	X		R-4.227
Metal purlin without thermal block	X		R-4.227
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.875
Metal joist/truss	R-5.284		R-4.051
Concrete slab or deck	NA		R-3.875
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-2.289
R-value continuous	NA	R-0.528	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-2.289	R-1.937
R-value continuous	R-1.057	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-2.289	R-2.289
R-value continuous	R-1.585	R-0.528	R-0

TABLE 6.2.2(20) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 40 % BUT NOT GREATER THAN 50% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	3.407		
Slab or below-grade wall (*R*-value)	R-1.409		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.4		0.704
0.25 ≤ PF < 0.50	0.5		0.704
PF ≥ 0.50	0.7		0.704
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-5.284		R-4.051
Metal joist/truss	R-5.284		R-4.227
Concrete slab or deck	NA		R-4.051
Metal purlin with thermal block	R-6.692		R-4.227
Metal purlin without thermal block	X		R-4.227
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.875
Metal joist/truss	R-5.284		R-4.051
Concrete slab or deck	NA		R-3.875
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-2.289
R-value continuous	NA	R-2.465	R-1.233
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-2.289	R-2.289
R-value continuous	R-1.761	R-0.528	R-0
Other masonry walls:			
R-value cavity	NA	R-2.289	R-2.289
R-value continuous	R-1.585	R-0.528	R-0.528

DD(F)=DD(C)*1.8; 1 W/m^2 · K = 0.1761 BTU/(hr.ft^2 · °F); 1 m^2 · K/W = 5.678 hr.ft^2 · °F/BTU

TABLE 6.2.2(21)
BUILDING ENVELOPE REQUIREMENTS FOR 4444 ≤ HDD/CDD (^oC) < 4722
WINDOW AND GLAZED DOOR AREA 10 % OR LESS
OF ABOVE-GRADE WALL AREA

Element	**Condition / Value**		
Skylights (*U*-factor)	3.407		
Slab or below-grade wall (*R*-value)	R-1.409		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.7		2.839
0.25 ≤ PF < 0.50	Any		2.839
PF ≥ 0.50	Any		2.839
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-5.284		R-4.051
Metal joist/truss	R-5.284		R-4.227
Concrete slab or deck	NA		R-4.051
Metal purlin with thermal block	X		R-4.227
Metal purlin without thermal block	X		R-4.227
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.875
Metal joist/truss	R-5.284		R-4.051
Concrete slab or deck	NA		R-3.875
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-2.289
R-value continuous	NA	R-0.528	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-2.289	R-1.937
R-value continuous	R-1.057	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-2.289	R-1.937
R-value continuous	R-1.057	R-0	R-0

TABLE 6.2.2(21) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 10 % BUT NOT GREATER THAN 25% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	3.407		
Slab or below-grade wall (*R*-value)	R-1.409		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.7		2.271
0.25 ≤ PF < 0.50	Any		2.271
PF ≥ 0.50	Any		2.271
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-5.284		R-4.051
Metal joist/truss	R-5.284		R-4.227
Concrete slab or deck	NA		R-4.051
Metal purlin with thermal block	X		R-4.227
Metal purlin without thermal block	X		R-4.227
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.875
Metal joist/truss	R-5.284		R-4.051
Concrete slab or deck	NA		R-3.875
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-2.289
R-value continuous	NA	R-0.528	R-0
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-2.289	R-1.937
R-value continuous	R-1.057	R-0	R-0
Other masonry walls:			
R-value cavity	NA	R-2.289	R-1.937
R-value continuous	R-1.585	R-0.528	R-0

TABLE 6.2.2(21) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 25 % BUT NOT GREATER THAN 40% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	3.407		
Slab or below-grade wall (*R*-value)	R-1.409		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.7		2.271
0.25 ≤ PF < 0.50	Any		2.271
PF ≥ 0.50	Any		2.271
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-5.284		R-4.051
Metal joist/truss	R-5.284		R-4.227
Concrete slab or deck	NA		R-4.051
Metal purlin with thermal block	X		R-4.227
Metal purlin without thermal block	X		R-4.227
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.875
Metal joist/truss	R-5.284		R-4.051
Concrete slab or deck	NA		R-3.875
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-2.289
R-value continuous	NA	R-0.704	R-0.528
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-2.289	R-2.289
R-value continuous	R-1.761	R-0.704	R-0.528
Other masonry walls:			
R-value cavity	NA	R-2.289	R-2.289
R-value continuous	R-1.761	R-0.704	R-0.528

TABLE 6.2.2(21) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 40 % BUT NOT GREATER THAN 50% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	3.407		
Slab or below-grade wall (*R*-value)	R-1.409		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**	***U*-factor**	
PF < 0.25	0.4	2.271	
0.25 ≤ PF < 0.50	0.5	2.271	
PF ≥ 0.50	0.7	2.271	
Roof assemblies (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	R-5.284	R-4.051	
Metal joist/truss	R-5.284	R-4.227	
Concrete slab or deck	NA	R-4.051	
Metal purlin with thermal block	R-6.692	R-4.227	
Metal purlin without thermal block	X	R-4.227	
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	R-4.403	R-3.875	
Metal joist/truss	R-5.284	R-4.051	
Concrete slab or deck	NA	R-3.875	
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-2.289
R-value continuous	NA	R-2.465	R-2.465
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-2.289	R-2.289
R-value continuous	R-2.465	R-1.761	R-1.233
Other masonry walls:			
R-value cavity	NA	R-2.289	R-2.289
R-value continuous	R-2.465	R-1.761	R-1.233

DD(F)=DD(C)*1.8; 1 $W/m^2 \cdot K$ = 0.1761 $BTU/(hr.ft^2 \cdot °F)$; 1 $m^2 \cdot K/W$ = 5.678 $hr.ft^2 \cdot °F/BTU$

TABLE 6.2.2(22)
BUILDING ENVELOPE REQUIREMENTS FOR 4722 ≤ HDD/CDD (^oC) < 5000
WINDOW AND GLAZED DOOR AREA 10 % OR LESS
OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	3.407		
Slab or below-grade wall (*R*-value)	R-2.113		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.7		3.407
0.25 ≤ PF < 0.50	Any		3.407
PF ≥ 0.50	Any		3.407
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-5.284		R-4.051
Metal joist/truss	R-5.284		R-4.227
Concrete slab or deck	NA		R-4.051
Metal purlin with thermal block	X		R-4.227
Metal purlin without thermal block	X		R-4.227
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.875
Metal joist/truss	R-5.284		R-4.051
Concrete slab or deck	NA		R-3.875
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-2.289
R-value continuous	NA	R-0.704	R-0.528
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-2.289	R-2.289
R-value continuous	R-1.585	R-0.528	R-0.528
Other masonry walls:			
R-value cavity	NA	R-2.289	R-2.289
R-value continuous	R-1.761	R-0.704	R-0.528

TABLE 6.2.2(22) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 10 % BUT NOT GREATER THAN 25% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	3.407		
Slab or below-grade wall (*R*-value)	R-2.113		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.7		2.271
0.25 ≤ PF < 0.50	Any		2.271
PF ≥ 0.50	Any		2.271
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-5.284		R-4.051
Metal joist/truss	R-5.284		R-4.227
Concrete slab or deck	NA		R-4.051
Metal purlin with thermal block	X		R-4.227
Metal purlin without thermal block	X		R-4.227
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.875
Metal joist/truss	R-5.284		R-4.051
Concrete slab or deck	NA		R-3.875
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-2.289
R-value continuous	NA	R-0.704	R-0.528
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-2.289	R-2.289
R-value continuous	R-1.585	R-0.528	R-0.528
Other masonry walls:			
R-value cavity	NA	R-2.289	R-2.289
R-value continuous	R-1.761	R-0.704	R-0.528

TABLE 6.2.2(22) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 25 % BUT NOT GREATER THAN 40% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	X		
Slab or below-grade wall (*R*-value)	X		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	X		X
0.25 ≤ PF < 0.50	X		X
PF ≥ 0.50	X		X
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	X		X
Metal joist/truss	X		X
Concrete slab or deck	X		X
Metal purlin with thermal block	X		X
Metal purlin without thermal block	X		X
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	X		X
Metal joist/truss	X		X
Concrete slab or deck	X		X
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	X	X
R-value continuous	NA	X	X
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	X	X	X
R-value continuous	X	X	X
Other masonry walls:			
R-value cavity	X	X	X
R-value continuous	X	X	X

TABLE 6.2.2(22) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 40 % BUT NOT GREATER THAN 50% OF ABOVE-GRADE WALL AREA

Element	**Condition / Value**		
Skylights (*U*-factor)	X		
Slab or below-grade wall (*R*-value)	X		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**	**_U_-factor**	
PF < 0.25	X	X	
0.25 ≤ PF < 0.50	X	X	
PF ≥ 0.50	X	X	
Roof assemblies (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	X	X	
Metal joist/truss	X	X	
Concrete slab or deck	X	X	
Metal purlin with thermal block	X	X	
Metal purlin without thermal block	X	X	
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	X	X	
Metal joist/truss	X	X	
Concrete slab or deck	X	X	
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	X	X
R-value continuous	NA	X	X
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	X	X	X
R-value continuous	X	X	X
Other masonry walls:			
R-value cavity	X	X	X
R-value continuous	X	X	X

DD(F) = DD(C)*1.8; 1 W/m^2 · K = 0.1761 BTU/(hr.ft^2 · °F); 1 m^2 · K/W = 5.678 hr.ft^2 · °F/BTU

TABLE 6.2.2(23)
BUILDING ENVELOPE REQUIREMENTS FOR HDD/CDD (°C) ≥ 5000
WINDOW AND GLAZED DOOR AREA 10 % OR LESS
OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	3.407		
Slab or below-grade wall (*R*-value)	R-2.113		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.7		2.839
0.25 ≤ PF < 0.50	Any		2.839
PF ≥ 0.50	Any		2.839
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-5.284		R-4.051
Metal joist/truss	R-5.284		R-4.227
Concrete slab or deck	NA		R-4.051
Metal purlin with thermal block	X		R-4.227
Metal purlin without thermal block	X		R-4.227
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.875
Metal joist/truss	R-5.284		R-4.051
Concrete slab or deck	NA		R-3.875
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-2.289
R-value continuous	NA	R-0.704	R-0.528
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-2.289	R-2.289
R-value continuous	R-1.585	R-0.528	R-0.528
Other masonry walls:			
R-value cavity	NA	R-2.289	R-2.289
R-value continuous	R-1.761	R-0.704	R-0.528

TABLE 6.2.2(23) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 10 % BUT NOT GREATER THAN 25% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	3.407		
Slab or below-grade wall (*R*-value)	R-2.113		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	0.7		2.271
0.25 ≤ PF < 0.50	Any		2.271
PF ≥ 0.50	Any		2.271
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-5.284		R-4.051
Metal joist/truss	R-5.284		R-4.227
Concrete slab or deck	NA		R-4.051
Metal purlin with thermal block	X		R-4.227
Metal purlin without thermal block	X		R-4.227
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	R-4.403		R-3.875
Metal joist/truss	R-5.284		R-4.051
Concrete slab or deck	NA		R-3.875
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	R-2.289	R-2.289
R-value continuous	NA	R-0.704	R-0.528
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	NA	R-2.289	R-2.289
R-value continuous	R-1.585	R-0.528	R-0.528
Other masonry walls:			
R-value cavity	NA	R-2.289	R-2.289
R-value continuous	R-1.761	R-0.704	R-0.528

TABLE 6.2.2(23) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 25 % BUT NOT GREATER THAN 40% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	X		
Slab or below-grade wall (*R*-value)	X		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**		***U*-factor**
PF < 0.25	X		X
0.25 ≤ PF < 0.50	X		X
PF ≥ 0.50	X		X
Roof assemblies (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	X		X
Metal joist/truss	X		X
Concrete slab or deck	X		X
Metal purlin with thermal block	X		X
Metal purlin without thermal block	X		X
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**		**Continuous insulation**
All-wood joist/truss	X		X
Metal joist/truss	X		X
Concrete slab or deck	X		X
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	X	X
R-value continuous	NA	X	X
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	X	X	X
R-value continuous	X	X	X
Other masonry walls:			
R-value cavity	X	X	X
R-value continuous	X	X	X

TABLE 6.2.2(23) (Continued)
WINDOW AND GLAZED DOOR AREA GREATER THAN 40 % BUT NOT GREATER THAN 50% OF ABOVE-GRADE WALL AREA

Element	Condition / Value		
Skylights (*U*-factor)	X		
Slab or below-grade wall (*R*-value)	X		
Windows and Glass doors	**Solar Heat Gain Factor (SHGC)**	**_U_-factor**	
PF < 0.25	X	X	
0.25 ≤ PF < 0.50	X	X	
PF ≥ 0.50	X	X	
Roof assemblies (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	X	X	
Metal joist/truss	X	X	
Concrete slab or deck	X	X	
Metal purlin with thermal block	X	X	
Metal purlin without thermal block	X	X	
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	X	X	
Metal joist/truss	X	X	
Concrete slab or deck	X	X	
Above-grade walls (*R*-value)	**No framing**	**Metal framing**	**Wood framing**
Framed: *R*-value cavity	NA	X	X
R-value continuous	NA	X	X
Concrete masonry units (CMU) ≥ 200 mm:			
R-value cavity	X	X	X
R-value continuous	X	X	X
Other masonry walls:			
R-value cavity	X	X	X
R-value continuous	X	X	X

DD(F) = DD(C)*1.8; 1 W/m^2 · K = 0.1761 BTU/(hr.ft^2 · °F); 1 m^2 · K/W = 5.678 hr.ft^2 · °F/BTU

6.2.3.2 **Curtain wall, storefront glazing and commercial entrance doors.** Curtain wall, storefront glazing and commercial-glazed swinging entrance doors and revolving doors shall be tested for air leakage at 75 Pa in accordance with (ASTM E 283). For curtain walls and storefront glazing, the maximum air leakage rate shall be 5.5 m^3/h·m^2 of fenestration area. For commercial glazed swinging entrance doors and revolving doors, the maximum air leakage rate shall be 18 m^3/h·m^2 of door area when tested in accordance with (ASTM E 283).

6.2.3.3 **Sealing of the building envelope.** Openings and penetrations in the building envelope shall be sealed with caulking materials or closed with gasketing systems compatible with the construction materials and location. Joints and seams shall be sealed in the same manner or taped or covered with a moisture vapor-permeable wrapping material. Sealing materials spanning joints between construction materials shall allow for expansion and contraction of the construction materials.

6.2.3.4 **Dampers integral to the building envelope.** Stair, elevator shaft vents, and other dampers integral to the building envelope shall be equipped with motorized dampers with a maximum leakage rate of 5 L/s · m^2 at 250 Pa when tested in accordance with (AMCA 500).

Exception: Gravity (non-motorized) dampers are permitted to be used in buildings less than three stories in height above grade.

6.2.3.5 **Loading dock weather seals.** Cargo doors and loading dock doors shall be equipped with weather seals to restrict infiltration when vehicles are parked in the doorway.

6.2.3.6 **Vestibules**. A door that separates conditioned space from the exterior shall be protected with an enclosed vestibule, with all doors opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior doors to open at the same time.

Exceptions:

1. Doors not intended to be used as a building entrance door, such as doors to mechanical or electrical equipment rooms.
2. Doors opening directly from a guestroom or dwelling unit.
3. Doors that open directly from a space less than 300 m^2 in area.
4. Revolving doors.
5. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.

6.2.3.7 **Recessed lighting fixtures.** When installed in the building envelope, recessed lighting fixtures shall meet one of the following requirements:

1. Type IC rated, manufactured with no penetrations between the inside of the recessed fixture and ceiling cavity and sealed or gasketed to prevent air leakage into the unconditioned space.
2. Type IC or non-IC rated, installed inside a sealed box constructed from a minimum 12.5 mm thick gypsum wallboard or constructed from a preformed polymeric vapor barrier, or other air-tight assembly manufactured for this purpose, while maintaining required clearances of not less than 12.5 mm from combustible material and not less than 75 mm from insulation material.
3. Type IC rated, in accordance with (ASTM E 283) admitting no more than 1 L/s of air movement from the conditioned space to the ceiling cavity. The lighting fixture shall be tested at 75 Pa pressure difference and shall be labeled.

SECTION 6.3
BUILDING MECHANICAL SYSTEMS

6.3.1 **General.** This section covers the design and construction of mechanical systems and equipment serving the building heating, cooling or ventilating needs.

6.3.1.1 **Compliance.** Compliance with Section 6.3 shall be achieved by meeting either Section 6.3.2 or 6.3.3.

6.3.2 **Simple HVAC systems and equipment.** This section applies to buildings served by unitary or packaged HVAC equipment listed in Tables 6.3.2.2(1) through 6.3.2.2(5), each serving one zone and controlled by a single thermostat in the zone served. It also applies to two-pipe heating systems serving one or more zones, where no cooling system is installed. This section does not apply to fan systems serving multiple zones, non-unitary or non-packaged HVAC equipment and systems or hydronic or steam heating and hydronic cooling equipment and distribution systems that provide cooling or cooling and heating which are covered by Section 6.3.3.

6.3.2.1 **Calculation of heating and cooling loads.** Design loads shall be determined in accordance with the procedures described in the ASHRAE *Fundamentals Handbook*. Heating and cooling loads shall be adjusted to account for load reductions that are achieved when energy recovery systems are utilized in the HVAC system in accordance with the ASHRAE *HVAC Systems and Equipment Handbook*. Alternatively, design loads shall be determined by an approved

equivalent computation procedure, using the design parameters specified in Chapter 2.

6.3.2.1.1 **Equipment and system sizing.** Heating and cooling equipment and systems capacity shall not exceed the loads calculated in accordance with Section 6.3.2.1. A single piece of equipment providing both heating and cooling must satisfy this provision for one function, with the capacity for the other function as small as possible, within available equipment options.

6.3.2.2 **HVAC equipment performance requirements.** Equipment shall meet the minimum efficiency requirements of Tables 6.3.2.2(1), 6.3.2.2(2), 6.3.2.2(3), 6.3.2.2(4) and 6.3.2.2(5), when tested and rated in accordance with the applicable test procedure. The efficiency shall be verified through data furnished by the manufacturer or through certification under an approved certification program. Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all stated requirements.

6.3.2.3 **Temperature and humidity controls.** Requirements for temperature and humidity controls shall be as specified in Sections 6.3.2.3.1 and 6.3.2.3.2.

6.3.2.3.1 **Temperature controls.** Each heating and cooling system shall have at least one solid-state programmable thermostat. The thermostat shall have the capability to set back or shut down the system based on day of the week and time of day, and provide a readily accessible manual override that will return to the pre-setback or shutdown schedule without reprogramming.

Exceptions:

1. HVAC systems serving hotel/motel guestrooms.

2. Packaged terminal air conditioners, packaged terminal heat pumps and room air conditioner systems.

6.3.2.3.2 **Heat pump supplementary heat.** Heat pumps having supplementary electric-resistance heat shall have controls that, except during defrost, prevent supplemental heat operation when the heat pump can meet the heating load.

6.3.2.3.3 **Humidity controls.** When humidistats are installed, they shall have the capability to prevent the use of fossil fuel or electric power to achieve a relative humidity below 60 % when the system controlled is cooling, and above 30 % when the system controlled is heating.

Exceptions:

1. Systems serving spaces where specific humidity levels are required to satisfy process needs, such as computer rooms, museums, surgical suites and buildings with refrigerating systems, such as supermarkets, refrigerated warehouses and ice arenas.

2. Systems where humidity is removed as the result of the use of a desiccant system with energy recovery.

3. Reheat systems utilizing site-recovered (including condenser heat) or site-solar energy sources.

6.3.2.4 **Hydronic system controls.** Hydronic systems of at least 175 kW design capacity supplying heated water to comfort conditioning systems shall include controls that meet the requirements of Section 6.3.3.3.7.

6.3.2.5 **Ventilation.** Ventilation, either natural or mechanical, shall be provided in accordance with Chapter 2 of the Saudi Building Code Mechanical Requirements SBC 501. Where mechanical ventilation is provided, the system shall provide the capability to reduce the outdoor air supply to the minimum required by Chapter 2 of the Saudi Building Code Mechanical Requirements SBC 501.

6.3.2.6 **Cooling with outdoor air.** Each system with a cooling capacity greater than 19 kW located in Zones with DDs more than 1700 (°C) shall have an economizer that will automatically shut off the cooling system and allow all of the supply air to be provided directly from outdoors. Economizers shall be capable of operating at

100 % outside air, even if additional mechanical cooling is required to meet the cooling load of the building. Where a single room or space is supplied by multiple air systems, the aggregate capacity of those systems shall be used in applying this requirement.

Exceptions:

1. Where the cooling equipment is covered by the minimum efficiency requirements of Table 6.3.2.2(1) or 6.3.2.2(2).
2. Systems with air or evaporatively cooled condensers and which serve spaces with open case refrigeration or that require filtration equipment in order to meet the minimum ventilation requirements of Chapter 2 of the Saudi Building Code Mechanical Requirements SBC 501.
3. Systems with a cooling capacity less than 40 kW with DDs in the range 550 – 3600.

TABLE 6.3.2.2 (1)
UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment type	Size category	Subcategory or rating condition	Minimum COP[b]	Test procedure
Air conditioners, Air cooled	< 19 kW	Split system	2.931 SCOP	(ARI 210/240)
		Single package	2.843 SCOP	
	≥ 19 kW and < 39.6 kW	Split system and Single package	3.019 COP[c]	
	≥ 39.6 kW and < 70.3 kW	Split system and Single package	2.843 COP[c]	(ARI 340/360)
	≥ 70.2 kW and < 222.7 kW	Split system and Single package	2.784 COP[c] 2.843 IPLV[c]	
	> 222.7 kW	Split system and Single package	2.697 COP[c] 2.755 IPLV[c]	
Air conditioners, Water and evaporatively cooled	< 19 kW	Split system and Single package	3.547 COP	(ARI 210/240)
	≥ 19 kW and < 39.6 kW	Split system and Single package	3.664 COP[c]	
	≥ 39.6 kW and < 70.3 kW	Split system and Single package	3.224 COP[c]	(ARI 340/360)
	≥ 70.3 kW	Split system and Single package	3.224 COP[c] 3.019 IPLV[c]	

b. IPLVs are only applicable to equipment with capacity modulation.

c. Deduct 0.0586 from the required COPs and IPLVs for units with a heating section other than electric resistance heat.

TABLE 6.3.2.2 (2)
UNITARY AND APPLIED HEAT PUMPS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment type	Size category	Subcategory or rating condition	Minimum COP[b]	Test procedure
Air cooled (Cooling mode)	< 19 kW	Split system	2.931 SCOP	(ARI 210/240)
		Single package	2.843 SCOP	
	≥ 19 kW and < 39.6 kW	Split system and Single package	2.960 COP[c]	
	≥ 39.6 kW and < 70.3 kW	Split system and Single package	2.726 COP[c]	(ARI 340/360)
	≥ 70.3 kW	Split system and Single package	2.638 COP[c] 2.697 IPLV[c]	
Water cooled (Cooling mode)	< 4.7 kW	30°C entering water	3.283 COP	(ARI/ASHRAE-13256-1)
	≥ 4.7 kW and < 37.7 kW	30°C entering water	3.517 COP	(ARI/ASHRAE-13256-1)
Groundwater source (Cooling mode)	< 37.7 kW	15°C entering water	4.748 COP	(ARI/ASHRAE-13256-1)
Ground source (Cooling mode)	< 37.7 kW	25°C entering water	3.928 COP	(ARI/ASHRAE-13256-1)
Air cooled (Heating mode)	< 19 kW (cooling capacity)	Split system	6.8 HSPF	(ARI 210/240)
		Single package	6.6 HSPF	
	≥ 19 kW and < 39.6 kW (Cooling capacity)	8.3°C db/6.1°C wb outdoor air	3.2 COP	
	≥ 39.6 kW (Cooling capacity)	8.3°C db/6.1°C wb outdoor air	3.1 COP	(ARI 340/360)
Water cooled (Heating mode)	< 39.6 kW (Cooling capacity)	20°C entering water	4.2 COP	(ARI/ASHRAE-13256-1)
Groundwater source (Heating mode)	< 39.6 kW (Cooling capacity)	10°C entering water	3.6 COP	(ARI/ASHRAE-13256-1)
Ground source (Heating mode)	< 39.6 kW (Cooling capacity)	0°C entering water	3.1 COP	(ARI/ASHRAE-13256-1)

b. IPLVs and Part load rating conditions are only applicable to equipment with capacity modulation.
c. Deduct 0.0586 from the required EERs and 0.2 from required IPLVs for units with a heating section other than electric resistance heat.

TABLE 6.3.2.2(3)
PACKAGED TERMINAL AIR CONDITIONERS AND PACKAGED TERMINAL HEAT PUMPS

Equipment type	Size category (input)	Subcategory or Rating condition	Minimum COP[b]	Test procedure
PTAC (Cooling mode) New construction	All capacities	35°C db outdoor air	3.664 - (0.213 · Cap) COP	(ARI 310/380)
PTAC (Cooling mode) Replacements[c]	All capacities	35°C db outdoor air	3.195 - (0.213 · Cap) COP	
PTHP (Cooling mode) New construction	All capacities	35°C db outdoor air	3.605 - (0.213 · Cap) COP	
PTHP (Cooling mode) Replacements[c]	All capacities	35°C db outdoor air	3.165 - (0.213 · Cap) COP	
PTHP (Heating mode) New construction	All capacities	-	3.2 - (0.0887 · Cap) COP	
PTHP (Heating mode) Replacements[c]	All capacities	-	2.9 - (0.0887 · Cap) COP	

db = dry-bulb temperature, °C, wb = wet-bulb temperature, °C

b. Cap means the rated cooling capacity of the product in W. If the unit's capacity is less than 2.1 kW, use 2.1 kW in the calculation. If the unit's capacity is greater than 4.4 kW, use 4.4 kW in the calculation.

c. Replacement units must be factory labeled as follows:
"MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY;
NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS."
Replacement efficiencies apply only to units with existing sleeves less than 400 mm high and less than 1050 mm wide.

TABLE 6.3.2.2(4)
WARM AIR FURNACES AND COMBINATION WARM AIR FURNACES/AIR-CONDITIONING UNITS, WARM AIR DUCT FURNACES AND UNIT HEATERS, MINIMUM EFFICIENCY REQUIREMENTS

Equipment type	Size category (input)	Subcategory or Rating condition	Minimum efficiency[b]
Warm air furnaces, gas fired	< 65.9 kW	-	78 % AFUE or 80 % E_t[c]
	≥ 65.9 kW	Maximum capacity[c]	80 % E_t[f]
Warm air furnaces, oil fired	< 65.9 kW	-	78 % AFUE or 80 % E_t[c]
	≥ 65.9 kW	Maximum capacity[b]	80 % E_t
Warm air duct furnaces, gas fired	All capacities	Maximum capacity[b]	80 % E_c
Warm air unit heaters, gas fired	All capacities	Maximum capacity[b]	80 % E_c
Warm air unit heaters, oil fired	All capacities	Maximum capacity[b]	80 % E_c

b. Minimum and maximum ratings as provided for and allowed by the unit's controls.

c. E_t = Thermal efficiency, see test procedure for detailed discussion.

d. E_c = Combustion efficiency (100% less flue losses), see test procedure for detailed discussion.

e. E_c = Combustion efficiency. Units must also include an IID, have jacket losses not exceeding 0.75 % of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.

f. E_t = Thermal efficiency. Units must also include an IID, have jacket losses not exceeding 0.75 % of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.

TABLE 6.3.2.2(5)
BOILERS, GAS- AND OIL-FIRED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment type[f]	Size category (input)	Subcategory or Rating condition	Minimum efficiency[c,d,e]
Boilers, gas fired	< 87.9 kW	Hot water	80 % AFUE
		Steam	75 % AFUE
	≥ 87.9 kW and ≤ 732.6 kW	Minimum capacity[b]	75 % E_t
	> 732.6 kW	Hot water	80 % E_c
		Steam	80 % E_c
Boilers, oil fired	< 87.9 kW	-	80 % AFUE
	≥ 87.9 kW and ≤ 732.6 kW	Minimum capacity[b]	78 % E_t
	> 732.6 kW	Hot water	83 % E_c
		Steam	83 % E_c
Boilers, oil fired (Residual)	≥ 87.9 kW and ≤ 732.6 kW	Minimum capacity[b]	78 % E_t
	> 732.6 kW	Hot water	83 % E_c
		Steam	83 % E_c

b. Minimum ratings as provided for and allowed by the unit's controls.
c. E_c = Combustion efficiency (100% less flue losses). See reference document for detailed information.
d. E_t = Thermal efficiency. See reference document for detailed information.
e. Alternative test procedures used at the manufacturer's option are ASME PTC-4.1 for units greater than 1460 kW input, or ANSI Z21.13 for units greater than or equal to 880 kW and less than or equal to 730 kW input.
f. These requirements apply to boilers with rated input of 2300 kW or less that are not packaged boilers, and to all packaged boilers. Minimum efficiency requirements for boilers cover all capacities of packaged boilers.

6.3.2.7 **Shutoff dampers.** Outdoor air supply and exhaust ducts shall be provided with automatic means to reduce and shutoff airflow.

Exceptions:

1. Systems serving areas designed for continuous operation.
2. Individual systems with a maximum 1400 L/s air flow rate.
3. Systems with readily accessible manual dampers.
4. Where restricted by health and life safety codes.

6.3.2.8 **Duct and plenum insulation and sealing.** All supply and return air ducts and plenums shall be insulated with a minimum of R-0.9 insulation when located in unconditioned spaces and with a minimum of R-1.4 insulation when located outside the building. When located within a building envelope assembly, the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by a minimum of R-1.4 insulation.

Exceptions:

1. When located within equipment.
2. When the design temperature difference between the interior and exterior of the duct or plenum does not exceed 8°C. All joints, longitudinal and transverse seams and connections in ductwork, shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems, or tapes. Tapes and mastics used to seal ductwork shall be listed and labeled in accordance with (UL 181A or UL 181B). Duct connections to flanges of air distribution system equipment shall be sealed and mechanically fastened. Unlisted duct tape is not permitted as a sealant on any metal ducts.

6.3.2.8.1 **Duct construction**. Ductwork shall be constructed and erected in accordance with the Saudi Building Code Mechanical Requirements SBC 501.

6.3.2.8.1.1 **High- and medium-pressure duct systems.** All ducts and plenums operating at a static pressures greater than 500 Pa shall be insulated and sealed in accordance with Section 6.3.2.8. Ducts operating at a static pressure in excess of 750 Pa shall be leak tested in accordance with Section 6.3.3.6. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the Saudi Building Code Mechanical Requirements SBC 501.

6.3.2.8.1.2 **Low-pressure duct systems.** All longitudinal and transverse joints, seams and connections of supply and return ducts operating at a static pressure less than or equal to 500 Pa shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems or tapes installed in accordance with the manufacturer's installation instructions. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the Saudi Building Code Mechanical Requirements SBC 501.

Exception: Continuously welded and locking-type longitudinal joints and seams on ducts operating at static pressures less than 500 Pa pressure classification.

6.3.2.9 **Piping insulation.** All piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Section 6.3.3.7.

6.3.3 **Complex HVAC systems and equipment.** This section applies to buildings served by HVAC equipment and systems not covered in Section 6.3.2.

6.3.3.1 **Calculation of heating and cooling loads.** Design loads shall be determined in accordance with Section 6.3.2.1.

6.3.3.1.1 **Equipment and system sizing.** Heating and cooling equipment and system capacity shall not exceed the loads calculated in accordance with Section 6.3.2.1.

Exceptions:

1. Required standby equipment and systems provided with controls and devices that allow such systems or equipment to operate automatically only when the primary equipment is not operating.
2. Multiple units of the same equipment type with combined capacities exceeding the design load and provided with controls that have the capability to sequence the operation of each unit based on load.

6.3.3.2 **HVAC equipment performance requirements.** Equipment shall meet the minimum efficiency requirements of Tables 6.3.3.2(1) through 6.3.3.2(6) and Table 6.3.2.2(5), when tested and rated in accordance with the applicable test procedure. The efficiency shall be verified through certification under an approved certification program or, if no certification program exists, the equipment efficiency ratings shall be supported by data furnished by the manufacturer. Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all stated requirements. Where components, such as indoor or outdoor coils, from different manufacturers are used, calculations and supporting data shall be furnished by the designers that demonstrate that the combined efficiency of the specified components meets the requirements herein. Where unitary or prepackaged equipment is used in a complex HVAC system and is not covered by Section 6.3.3.2, the equipment shall meet the applicable requirements of Section 6.3.2.2.

Exception: Equipment listed in Table 6.3.3.2(2) not designed for operation at ARI Standard test conditions of 7°C leaving chilled water temperature and 29°C entering condenser water temperature shall have a minimum full load COP and IPLV rating as shown in Tables 6.3.3.2(3) through 6.3.3.2(5) as applicable. The table values are only applicable over the following full load design ranges: Leaving Chilled Water Temperature: 4 to 9°C.

Entering Condenser Water Temperature: 24 to 29°C.
Condensing Water Temperature Rise: 3 to 8°C.
Chillers designed to operate outside of these ranges are not covered by this requirement.

TABLE 6.3.3.2(1)
CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Minimum Efficiency[b]	Test Procedure
Condensing units, air cooled	≥ 39.6 kW	10.1 EER 3.283 IPLV	(ARI 365)
Condensing units, water or evaporatively cooled	≥ 39.6 kW	3.840 EER 3.840 IPLV	

b. IPLVs are only applicable to equipment with capacity modulation.

TABLE 6.3.3.2(2)
WATER CHILLING PACKAGES, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Minimum Efficiency[b]	Test Procedure
Air cooled, with condenser, Electrically operated	< 150 tons	2.80 COP 2.80 IPLV	(ARI 550/590)
	≥ 150 tons	2.50 COP 2.50 IPLV	
Air cooled, without condenser, Electrically operated	All capacities	3.10 COP 3.10 IPLV	(ARI 550/590)
Water cooled, Electrically operated, Positive displacement (reciprocating)	All capacities	4.20 COP 4.65 IPLV	
Water cooled, Electrically operated, Positive displacement (rotary screw and scroll)	< 150 tons	4.45 COP 4.50 IPLV	(ARI 550/590)
	≥ 150 tons and < 300 tons	4.90 COP 4.95 IPLV	
	≥ 300 tons	5.50 COP 5.60 IPLV	
Water cooled, Electrically operated, Centrifugal	< 150 tons	5.00 COP 5.50 IPLV	(ARI 550/590)
	≥ 150 tons and < 300 tons	5.55 COP 5.55 IPLV	
	≥ 300 tons	6.10 COP 6.10 IPLV	
Air cooled, absorption, single effect	All capacities	0.60 COP	(ARI 560)
Water cooled, absorption, single effect	All capacities	0.70 COP	
Absorption, double effect, indirect fired	All capacities	1.00 COP 1.05 IPLV	
Absorption, double effect, direct fired	All capacities	1.00 COP 1.00 IPLV	

1 ton = 3.517 kW

b. The chiller equipment requirements do not apply for chillers used in low-temperature applications where the design leaving fluid temperature is less than or equal to 4.5°C.

TABLE 6.3.3.2(3)
COPS AND IPLVS FOR NON-STANDARD CENTRIFUGAL CHILLERS < 150 TONS

Centrifugal Chillers < 150 tons COP_{std} = 5.4								
Leaving chilled water Temperature °C	Entering condenser water Temperature °C	Lift[a] (°C)	Condenser Flow Rate					
			0.126 L/s.ton	0.1578 L/s.ton	0.189 L/s.ton	0.252 L/s.ton	0.315 L/s.ton	0.379 L/s.ton
			Required COP and IPLV					
7.78	23.89	16.11	6.00	6.27	6.48	6.80	7.03	7.20
7.22	23.89	16.67	5.92	6.17	6.37	6.66	6.87	7.02
6.67	23.89	17.22	5.84	6.08	6.26	6.53	6.71	6.86
6.11	23.89	17.78	5.75	5.99	6.16	6.40	6.58	6.71
5.56	23.89	18.33	5.67	5.90	6.06	6.29	6.45	6.57
5.00	23.89	18.89	5.59	5.82	5.98	6.19	6.34	6.44
7.78	26.67	18.89	5.59	5.82	5.98	6.19	6.34	6.44
4.44	23.89	19.44	5.50	5.74	5.89	6.10	6.23	6.33
7.22	26.67	19.44	5.50	5.74	5.89	6.10	6.23	6.33
6.67	26.67	20.00	5.41	5.66	5.81	6.01	6.13	6.22
6.11	26.67	20.56	5.31	5.57	5.73	5.92	6.04	6.13
5.56	26.67	21.11	5.21	5.48	5.64	5.84	5.95	6.04
5.00	26.67	21.67	5.09	5.39	5.56	5.76	5.87	5.95
7.78	29.44	21.67	5.09	5.39	5.56	5.76	5.87	5.95
4.44	26.67	22.22	4.96	5.29	5.47	5.67	5.79	5.86
7.22	29.44	22.22	4.96	5.29	5.47	5.67	5.79	5.86
6.67	29.44	22.78	4.83	5.18	5.40	5.59	5.71	5.78
6.11	29.44	23.33	4.68	5.07	5.28	5.50	5.62	5.70
5.56	29.44	23.89	4.51	4.94	5.17	5.41	5.54	5.62
5.00	29.44	24.44	4.33	4.80	5.05	5.31	5.45	5.53
4.44	29.44	25.00	4.13	4.65	4.92	5.21	5.35	5.44
Condenser ΔT[b]			14.04	11.23	9.36	7.02	5.62	4.68

a. Lift = Entering condenser water temperature (°C) – Leaving chilled water temperature (°C).

b. Condenser ΔT = Leaving condenser water temperature (°C) – Entering condenser water temperature (°C).
$Kadj = 6.1507 - 0.544392*(X) + 0.020312208*(X)^2 - 0.00026591004*(X)^3$
where X = Condenser ΔT + Lift

TABLE 6.3.3.2(4)
COPS AND IPLVS FOR NON-STANDARD CENTRIFUGAL CHILLERS ≥ 150 TONS, ≤ 300 TONS

Centrifugal Chillers ≥ 150 tons, ≤ 300 tons COP_{std} = 5.55								
Leaving chilled water temperature °C	**Entering condenser water temperature °C**	**Lift[a] (°C)**	**Condenser Flow Rate**					
			0.126 L/s.ton	**0.1578 L/s.ton**	**0.189 L/s.ton**	**0.252 L/s.ton**	**0.315 L/s.ton**	**0.379 L/s.ton**
			Required COP and IPLV					
7.78	23.89	16.11	6.17	6.44	6.66	6.99	7.23	7.40
7.22	23.89	16.67	6.08	6.34	6.54	6.84	7.06	7.22
6.67	23.89	17.22	6.00	6.24	6.43	6.71	6.90	7.05
6.11	23.89	17.78	5.91	6.15	6.33	6.58	6.76	6.89
5.56	23.89	18.33	5.83	6.07	6.23	6.47	6.63	6.75
5.00	23.89	18.89	5.74	5.98	6.14	6.36	6.51	6.62
7.78	26.67	18.89	5.74	5.98	6.14	6.36	6.51	6.62
4.44	23.89	19.44	5.65	5.90	6.05	6.26	6.40	6.51
7.22	26.67	19.44	5.65	5.90	6.05	6.26	6.40	6.51
6.67	26.67	20.00	5.56	5.81	5.97	6.17	6.30	6.40
6.11	26.67	20.56	5.46	5.73	5.89	6.08	6.21	6.30
5.56	26.67	21.11	5.35	5.64	5.80	6.00	6.12	6.20
5.00	26.67	21.67	5.23	5.54	5.71	5.91	6.03	6.11
7.78	29.44	21.67	5.23	5.54	5.71	5.91	6.03	6.11
4.44	26.67	22.22	5.10	5.44	5.62	5.83	5.95	6.03
7.22	29.44	22.22	5.10	5.44	5.62	5.83	5.95	6.03
6.67	29.44	22.78	4.96	5.33	5.55	5.74	5.86	5.94
6.11	29.44	23.33	4.81	5.21	5.42	5.66	5.78	5.86
5.56	29.44	23.89	4.63	5.08	5.31	5.56	5.69	5.77
5.00	29.44	24.44	4.45	4.93	5.19	5.46	5.60	5.69
4.44	29.44	25.00	4.24	4.77	5.06	5.35	5.50	5.59
Condenser ΔT[b]			14.04	11.23	9.36	7.02	5.62	4.68

a. Lift = Entering condenser water temperature (°C) – Leaving chilled water temperature (°C).

b. Condenser ΔT = Leaving condenser water temperature (°C) – Entering condenser water temperature (°C).
$Kadj = 6.1507 - 0.544392*(X) + 0.020312208 * (X)^2 - 0.00026591004*(X)^3$
where X = Condenser ΔT + Lift
$COP_{adj} = K_{adj} \times COP_{std}$

TABLE 6.3.3.2(5)
COPS AND IPLVS FOR NON-STANDARD CENTRIFUGAL CHILLERS > 300 TONS

Centrifugal Chillers > 300 tons COP_{std} = 6.1								
Leaving chilled water Temperature °C	Entering condenser water Temperature °C	Lift[a] (°C)	Condenser Flow Rate					
			0.126 L/s.ton	0.1578 L/s.ton	0.189 L/s.ton	0.252 L/s.ton	0.315 L/s.ton	0.379 L/s.ton
			Required COP and IPLV					
7.78	23.89	16.11	6.80	7.11	7.35	7.71	7.97	8.16
7.22	23.89	16.67	6.71	6.99	7.21	7.55	7.78	7.96
6.67	23.89	17.22	6.61	6.89	7.09	7.40	7.61	7.77
6.11	23.89	17.78	6.52	6.79	6.98	7.26	7.45	7.60
5.56	23.89	18.33	6.43	6.69	6.87	7.13	7.31	7.44
5.00	23.89	18.89	6.33	6.60	6.77	7.02	7.18	7.30
7.78	26.67	18.89	6.33	6.60	6.77	7.02	7.18	7.30
4.44	23.89	19.44	6.23	6.50	6.68	6.91	7.06	7.17
7.22	26.67	19.44	6.23	6.50	6.68	6.91	7.06	7.17
6.67	26.67	20.00	6.13	6.41	6.58	6.81	6.95	7.05
6.11	26.67	20.56	6.02	6.31	6.49	6.71	6.85	6.94
5.56	26.67	21.11	5.90	6.21	6.40	6.61	6.75	6.84
5.00	26.67	21.67	5.77	6.11	6.30	6.52	6.65	6.74
7.78	29.44	21.67	5.77	6.11	6.30	6.52	6.65	6.74
4.44	26.67	22.22	5.63	6.00	6.20	6.43	6.56	6.65
7.22	29.44	22.22	5.63	6.00	6.20	6.43	6.56	6.65
6.67	29.44	22.78	5.47	5.87	6.10	6.33	6.47	6.55
6.11	29.44	23.33	5.30	5.74	5.98	6.24	6.37	6.46
5.56	29.44	23.89	5.11	5.60	5.86	6.13	6.28	6.37
5.00	29.44	24.44	4.90	5.44	5.72	6.02	6.17	6.27
4.44	29.44	25.00	4.68	5.26	5.58	5.90	6.07	6.17
Condenser ΔT[b]			14.04	11.23	9.36	7.02	5.62	4.68

a. Lift = Entering condenser water temperature (°C) – Leaving chilled water temperature (°C).

b. Condenser ΔT = Leaving condenser water temperature (°C) – Entering condenser water temperature (°C).

$K_{adj} = 6.1507 - 0.544392 \cdot (X) + 0.020312208 \cdot (X)^2 - 0.00026591004 \cdot (X)^3$

where X = Condenser ΔT + Lift

$COP_{adj} = K_{adj} \times COP_{std}$

TABLE 6.3.3.2(6)
PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT

Equipment Type	Total System Heat Rejection Capacity at Rated Condition	Subcategory of Rated Condition	Performance Required[a,b]	Test Procedure
Propeller or axial fan cooling towers	All	35°C entering water 29.4°C leaving water 23.9°C wb outdoor air	≥ 32.32 L/(s·kW)	(CTI ATC-105 and CTI STD-201)
Centrifugal an cooling towers	All	35°C entering water 29.4°C leaving water 23.9°C wb outdoor air	≥ 16.92 L/(s·kW)	(CTI ATC-105 and CTI STD-201)
Air-cooled condensers	All	51.7°C condensing temperature R22 test fluid 87.8°C entering gas temperature -9.4°C subcooling 35°C entering db	≥ 69 COP	(ARI 460)

a. For purposes of this table, cooling tower performance is defined as the maximum flow rating of the tower units (L/s) divided by the fan nameplate rated motor power (kW).
b. For purposes of this table, air-cooled condenser performance is defined as the heat rejected from the refrigerant units (kW) divided by the fan nameplate rated motor power (kW).

6.3.3.3 **HVAC system controls.** Each heating and cooling system shall be provided with thermostatic controls as required in Sections 6.3.3.3.1 through 6.3.3.3.5.

6.3.3.3.1 **Thermostatic controls.** The supply of heating and cooling energy to each zone shall be controlled by individual thermostatic controls capable of responding to temperature within the zone. Where humidification or dehumidification or both is provided, at least one humidity control device shall be provided for each humidity control system.

Exception: Independent perimeter systems that are designed to offset only building envelope heat losses or gains or both serving one or more perimeter zones also served by an interior system provided:

1. The perimeter system includes at least one thermostatic control zone for each building exposure having exterior walls facing only one orientation (within +/- 45 degrees) (0.8 rad) for more than 15 m contiguous; and
2. The perimeter system heating and cooling supply is controlled by a thermostat(s) located within the zone(s) served by the system.

6.3.3.3.1.1 **Heat pump supplementary heat.** Heat pumps having supplementary electric resistance heat shall have controls that, except during defrost, prevent supplementary heat operation when the heat pump can meet the heating load.

6.3.3.3.2 **Set point overlap restriction.** Where used to control both heating and cooling, zone thermostatic controls shall provide a temperature range or dead band of at least 2.8°C within which the supply of heating and cooling energy to the zone is capable of being shutoff or reduced to a minimum.

Exception: Thermostats requiring manual changeover between heating and cooling modes.

6.3.3.3.3 **Off-hour controls.** Each zone shall be provided with thermostatic setback controls that are controlled by either an automatic time clock or programmable control system.

Exceptions:

1. Zones that will be operated continuously.
2. Zones with a full HVAC load demand not exceeding 2 kW and having a readily accessible manual shutoff switch.

6.3.3.3.3.1 **Thermostatic setback capabilities.** Thermostatic setback controls shall have the capability to set back or temporarily operate the system to maintain zone temperatures down to 13°C or up to 29°C.

6.3.3.3.3.2 **Automatic setback and shutdown capabilities.** Automatic time clock or programmable controls shall be capable of starting and stopping the system for seven different daily schedules per week and retaining their programming and time setting during a loss of power for at least 10 hours. Additionally, the controls shall have: a manual override that allows temporary operation of the system for up to 2 hours; a manually operated timer capable of being adjusted to operate the system for up to 2 hours; or an occupancy sensor.

6.3.3.3.4 **Shutoff damper controls.** Both outdoor air supply and exhaust ducts shall be equipped with gravity or motorized dampers that will automatically shut when the systems or spaces served are not in use.

Exception: Individual supply systems with a design airflow rate of 1400 L/s or less.

6.3.3.3.5 **Economizers.** Economizers shall be provided on each system with a cooling capacity greater than 19 kW in accordance with Section 6.3.2.6.

Exceptions:

1. Water economizers that are capable of cooling supply air by direct or indirect evaporation or both and providing up to 100 % of the expected system cooling load at outside air temperatures of 10°C dry bulb 7°C wet bulb and below.
2. Systems with a cooling capacity less than 40 kW in Climate Zones with DDs in the range 550 – 3600.

6.3.3.3.6 **Variable air volume (VAV) fan control.** Individual VAV fans with motors of 19 kW or greater shall be:

1. Driven by a mechanical or electrical variable speed drive; or
2. The fan motor shall have controls or devices that will result in fan motor demand of no more than 30 % of their design wattage at 50 % of design airflow when static pressure set point equals one-third of the total design static pressure, based on manufacturer's certified fan data.

6.3.3.3.7 **Hydronic systems controls.** The heating of fluids that have been previously mechanically cooled and the cooling of fluids that have been previously mechanically heated shall be limited in accordance with Sections 6.3.3.3.7.1 through 6.3.3.3.7.3. Hydronic heating systems comprised of multiple-packaged boilers and designed to deliver conditioned water or steam into a common distribution system shall include automatic controls capable of sequencing operation of the boilers. Hydronic heating systems comprised of a single boiler and greater than 145 kW input design capacity shall include either a multi-staged or modulating burner.

6.3.3.3.7.1 **Three-pipe system.** Hydronic systems that use a common return system for both hot water and chilled water are prohibited.

6.3.3.3.7.2 **Two-pipe changeover system.** Systems that use a common distribution system to supply both heated and chilled water shall be designed to allow a dead band between changeover from one mode to the other of at least 8°C outside air temperatures; be designed to and provided with controls that will allow operation in one mode for at least 4 hours before changing over to the other mode; and be provided with controls that allow heating and cooling supply temperatures at the changeover point to be no more than 16°C apart.

6.3.3.3.7.3 **Hydronic (water loop) heat pump systems** Hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection and heat addition shall have controls that are capable of providing a heat pump water supply temperature dead band of at least 10°C between initiation of heat rejection and heat addition by the central devices. For Climate Zones with DDs exceeding 1100,

if a closed-circuit cooling tower is used, either an automatic valve shall be installed to bypass all but a minimal flow of water around the tower, or lower leakage positive closure dampers shall be provided. If an open-circuit tower is used directly in the heat pump loop, an automatic valve shall be installed to bypass all heat pump water flow around the tower. If an open-circuit cooling tower is used in conjunction with a separate heat exchanger to isolate the cooling tower from the heat pump loop, then heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop. Each hydronic heat pump on the hydronic system having a total pump system power exceeding 7.5 kW shall have a two-position valve.

Exception: Where a system loop temperature optimization controller is installed and can determine the most efficient operating temperature based on real time conditions of demand and capacity, dead bands of less than 10°C shall be permitted.

6.3.3.3.7.4 **Part load controls.** Hydronic systems greater than or equal to 88,000 W in design capacity supplying heated or chilled water to comfort conditioning systems shall include controls that have the capability to:

1. Automatically reset the supply water temperatures using zone return water temperature, building return water temperature, or outside air temperature as an indicator of building heating or cooling demand. The temperature shall be capable of being reset by at least 25 % of the design supply-to-return water temperature difference; or
2. Reduce system pump flow-by at least 50 % of design flow rate utilizing adjustable speed drive(s) on pump(s), multiple staged pumps where at least one-half of the total pump horsepower is capable of being automatically turned off, control valves designed to modulate or step down, and close, as a function of load, or other approved means.

6.3.3.3.7.5 **Pump isolation.** Chilled water plants including more than one chiller shall have the capability to reduce flow automatically through the chiller plant when a chiller is shut down. Chillers piped in series for the purpose of increased temperature differential, shall be considered as one chiller. Boiler plants including more than one boiler shall have the capability to reduce flow automatically through the boiler plant when a boiler is shutdown.

6.3.3.3.8 **Heat rejection equipment fan speed control.** Each fan powered by a motor of 6 kW or larger shall have the capability to operate that fan at two-thirds of full speed or less, and shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device.

Exception: Factory-installed heat rejection devices within HVAC equipment tested and rated in accordance with Tables 6.3.3.2(1) through 6.3.3.2(6).

6.3.3.4 **Requirements for complex mechanical systems serving multiple zones.** Sections 6.3.3.4.1 through 6.3.3.4.3 shall apply to complex mechanical systems serving multiple zones. Supply air systems serving multiple zones shall be VAV systems which, during periods of occupancy, are designed and capable of being controlled to reduce primary air supply to each zone to one of the following before reheating, re-cooling or mixing takes place:

1. 30 % of the maximum supply air to each zone.
2. 140 L/s or less where the maximum flow rate is less than 10 % of the total fan system supply airflow rate.
3. The minimum ventilation requirements of Chapter 2 of the Saudi Building Code Mechanical Requirements SBC 501.

Exception: The following define when individual zones or when entire air distribution systems are exempted from the requirement for VAV control:

1. Zones where special pressurization relationships or cross-contamination requirements are such that VAV systems are impractical.
2. Zones or supply air systems where at least 75 % of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered or site-solar energy source.
3. Zones where special humidity levels are required to satisfy process needs.
4. Zones with a peak supply air quantity of 140 L/s or less and where the flow rate is less than 10 % of the total fan system supply airflow rate.
5. Zones where the volume of air to be reheated, re-cooled or mixed is no greater than the volume of outside air required to meet the minimum ventilation requirements of Chapter 4 of the Saudi Building Code Mechanical Requirements SBC 501.
6. Zones or supply air systems with thermostatic and humidistatic controls capable of operating in sequence the supply of heating and cooling energy to the zone(s) and which are capable of preventing reheating, re-cooling, mixing or simultaneous supply of air that has been previously cooled, either mechanically or through the use of economizer systems, and air that has been previously mechanically heated.

6.3.3.4.1 **Single duct variable air volume (VAV) systems, terminal devices.** Single duct VAV systems shall use terminal devices capable of reducing the supply of primary supply air before reheating or re-cooling takes place.

6.3.3.4.2 **Dual duct and mixing VAV systems, terminal devices.** Systems that have one warm air duct and one cool air duct shall use terminal devices which are capable of reducing the flow from one duct to a minimum before mixing of air from the other duct takes place.

6.3.3.4.3 **Single fan dual duct and mixing VAV systems, economizers.** Individual dual duct or mixing heating and cooling systems with a single fan and with total capacities greater than 26,375 W (7.5 tons) shall not be equipped with air economizers.

6.3.3.5 **Ventilation.** Ventilation shall be in accordance with Section 6.3.2.5.

6.3.3.6 **Duct and plenum insulation and sealing.** All ducts and plenums shall be insulated and sealed in accordance with Section 6.3.2.8. Ducts designed to operate at static pressures in excess of 746 Pa shall be leak-tested in accordance with the SMACNA *HVAC Air Duct Leakage Test Manual* with the rate of air leakage (*CL*) less than or equal to 0.011 as determined in accordance with Equation 6-2.

$$CL = F \times P^{0.65} \qquad \textbf{(Equation 6-2)}$$

Where:

F = The measured leakage rate in m^3/s per m^2 of duct surface.

P = The static pressure of the test, Pa.

Documentation shall be furnished by the designer demonstrating that representative sections totaling at least 25 % of the duct area have been tested and that all tested sections meet the requirements of this section.

6.3.3.7 **Piping insulation.** All piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Table 6.3.3.7.

Exceptions:

1. Factory-installed piping within HVAC equipment tested and rated in accordance with a test procedure referenced by this requirement.
2. Piping that conveys fluids that have a design operating temperature range between 13°C and 40°C.
3. Piping that conveys fluids that have not been heated or cooled through the use of fossil fuels or electric power.

4. Run-out piping not exceeding 1200 mm in length and 25 mm in diameter between the control valve and HVAC coil.

6.3.3.8 **HVAC system completion.** Prior to the issuance of a certificate of occupancy, the design professional shall provide evidence of system completion in accordance with Sections 6.3.3.8.1 through 6.3.3.8.3.

TABLE 6.3.3.7
MINIMUM PIPE INSULATION[a] (thickness in mm)

Fluid	Nominal pipe diameter	
	≤ 38 (1.5 inches)	> 38 (1.5 inches)
Steam	38	76
Hot water	25	50
Chilled water, brine or refrigerant	25	38

a. Based on insulation having a conductivity (k) not exceeding 0.0604 W/($m^2 \cdot K$) per mm.

6.3.3.8.1 **Air system balancing.** Each supply air outlet and zone terminal device shall be equipped with means for air balancing in accordance with the requirements of the Saudi Building Code Mechanical Requirements SBC 501. Discharge dampers are prohibited on constant volume fans and variable volume fans with motors 19 kW and larger.

6.3.3.8.2 **Hydronic system balancing.** Individual hydronic heating and cooling coils shall be equipped with means for balancing and pressure test connections.

6.3.3.8.3 **Manuals.** The construction documents shall require that an operating and maintenance manual be provided to the building owner by the mechanical contractor. The manual shall include, at least, the following:

1. Equipment capacity (input and output) and required maintenance actions.
2. Equipment operation and maintenance manuals.
3. HVAC system control maintenance and calibration information, including wiring diagrams, schematics, and control sequence descriptions. Desired or field-determined set points shall be permanently recorded on control drawings, at control devices or, for digital control systems, in programming comments.
4. A complete written narrative of how each system is intended to operate.

6.3.3.9 **Heat recovery for service water heating.** Condenser heat recovery shall be installed for heating or reheating of service hot water provided the facility operates 24 hours a day, the total installed heat capacity of water-cooled systems exceeds 1750 kW of heat rejection, and the design service water heating load exceeds 300 kW. The required heat recovery system shall have the capacity to provide the smaller of:

1. 60 % of the peak heat rejection load at design conditions; or
2. The preheating required to raise the peak service hot water draw to 29°C.

Exceptions:

1. Facilities that employ condenser heat recovery for space heating or reheat purposes with a heat recovery design exceeding 30 % of the peak water-cooled condenser load at design conditions.
2. Facilities that provide 60 % of their service water heating from site solar or site recovered energy or from other sources.

SECTION 6.4
SERVICE WATER HEATING

6.4.1 **General.** This section covers the efficiency the minimum efficiency of, and controls for, service water-heating equipment and insulation of service hot water piping.

6.4.2 **Service water-heating equipment performance efficiency.** Water-heating equipment and hot water storage tanks shall meet the requirements of Table 6.4.2. The efficiency shall be verified through data furnished by the manufacturer or through certification under an approved certification program.

TABLE 6.4.2
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED[b]	TEST PROCEDURE
Water heaters, Electric	≤ 12 kW	Resistance	0.93 - 0.00035V, EF	(DOE 10 CFR Part 430)
	> 12 kW	Resistance	0.134 V + 45.4, SL, W	(ANSI Z21.103)
	≤ 24 amps and ≤ 250 volts	Heat pump	0.93 - 0.00035V, EF	(DOE 10 CFR Part 430)
Storage water heaters, Gas	≤ 22000 W	≥ 76 L	0.62 - 0.00051V, EF	(DOE 10 CFR Part 430)
	>22000 W	< 312 W/L	80% E_t ,	(ANSI Z21.10.3)
Instantaneous water heaters, Gas	>14500 W and < 59000 W	312 W/L	0.62 - 0.00051V, EF	(DOE 10 CFR Part 430)
	≥ 61000 W	≥ 312 W/L and < 38 L	80% E_t ,	(ANSI Z21.10.3)
Storage water heaters, Oil	≤ 31000 W	≥ 76 L	0.59 - 0.00051V, EF	(DOE 10 CFR Part 430)
	> 31000 W	< 312 W/L	78% E_t ,	(ANSI Z21.10.3)
Instantaneous water heaters, Oil	≤ 61000 W	≥ 312 W/L and < 7.6 L	0.59 - 0.00051V, EF	(DOE 10 CFR Part 430)
	> 61000 W	≥ 312 W/L and < 38 L	80% E_t ,	(ANSI Z21.10.3)
Hot water supply boilers, Gas and Oil	≥ 88,000 W and < 3,600,000 W	≥ 312 W/L and < 38 L	80% E_t ,	(ANSI Z21.10.3)
Pool heaters, Gas and Oil	All	—	78% E_t	(ASHRAE 146)
Unfired storage tanks	All	—	≤ 20.5 W/m^2	(none)

a. Energy factor (EF) and thermal efficiency (*Et*) are minimum requirements. In the EF equation, *V* is the rated volume in liters.
b. Standby loss (SL) is the maximum Btu/h based on a nominal 49°C temperature difference between stored water and ambient requirements. In the SL equation for electric water heaters, *V* is the rated volume in liters.
c. Instantaneous water heaters with input rates below 61,000 W must comply with these requirements if the water heater is designed to heat water to temperatures 82°C or higher.

6.4.3 **Temperature controls.** Service water-heating equipment shall be provided with controls to allow a set-point of 43°C for equipment serving dwelling units and 32°C for equipment serving other occupancies. The outlet temperature of lavatories in public facility rest rooms shall be limited to 43°C.

6.4.4 **Heat traps.** Water-heating equipment not supplied with integral heat traps and serving non-circulating systems shall be provided with heat traps on the supply and discharge piping associated with the equipment.

6.4.5 **Pipe insulation.** For automatic-circulating hot water systems, piping shall be insulated with 25 mm of insulation having a conductivity not exceeding 1.53 W per 25 mm/m^2 · K. The first 2.43 m of piping in non-circulating systems served by equipment without integral heat traps shall be insulated with 12.7 mm of material having a conductivity not exceeding 1.53 W per 25 mm/m^2 · K.

6.4.6 **Hot water system controls.** Automatic-circulating hot water system pumps or heat trace shall be arranged to be conveniently turned off automatically or manually when the hot water system is not in operation.

SECTION 6.5
ELECTRICAL POWER AND LIGHTING SYSTEMS

6.5.1 **General.** This section covers lighting system controls, the connection of ballasts, the maximum lighting power for interior applications, and minimum acceptable lighting equipment for exterior applications.

Exception:

1. Lighting within dwelling units.
2. Emergency lighting.
3. Essential lighting in health care facilities.

6.5.2 **Lighting controls.** Lighting systems shall be provided with controls as required in Sections 6.5.2.1, 6.5.2.2 and 6.5.2.3.

6.5.2.1 **Interior lighting controls.** Each area enclosed by walls or floor-to-ceiling partitions shall have at least one manual control for the lighting serving that area. The required controls shall be located within the area served by the controls or be a remote switch that identifies the lights served and indicates their status.

Exceptions:

1. Areas designated as security or emergency areas that must be continuously lighted.
2. Lighting in stairways or corridors that are elements of the means of egress.

6.5.2.2 **Additional controls.** Each area that is required to have a manual control shall have additional controls that meet the requirements of Sections 6.5.2.2.1, 6.5.2.2.2 and 6.5.2.2.3.

Exceptions:

1. Areas that have only one luminaire.
2. Areas that are controlled by an occupant-sensing device.
3. Corridors, storerooms, restrooms or public lobbies.

6.5.2.2.1 **Light reduction controls.** Each area that is required to have a manual control shall also allow the occupant to reduce the connected lighting load in a reasonably uniform illumination pattern by at least 50 percent. Lighting reduction shall be achieved by one of the following or other approved methods:

1. Controlling all lamps or luminaries;
2. Dual switching of alternate rows of luminaires, alternate luminaires or alternate lamps;
3. Switching the middle lamp luminaires independently of the outer lamps; or
4. Switching each luminaire or each lamp.

Exceptions:

1. Areas that have only one luminaire.

2. Areas that are controlled by an occupant-sensing device.
3. Corridors, storerooms, restrooms or public lobbies.
4. Guestrooms.
5. Spaces that use less than 6.5 W/m^2.

6.5.2.2.2 **Automatic lighting shutoff.** Buildings larger than 465 m^2 shall be equipped with an automatic control device to shut off lighting in those areas. This automatic control device shall function on either:

1. a scheduled basis, using time-of-day, with an independent program schedule that controls the interior lighting in areas that do not exceed 2323 m^2 and are not more than one floor; or
2. an unscheduled basis by occupant intervention.

6.5.2.2.2.1 **Occupant override.** Where an automatic time switch control device is installed to comply with Section 6.5.2.2.2, Item 1, it shall incorporate an override switching device that:

1. is readily accessible.
2. is located so that a person using the device can see the lights or the area controlled by that switch, or so that the area being lit is annunciated.
3. is manually operated.
4. allows the lighting to remain on for no more than 2 hours when an override is initiated.
5. controls an area not exceeding 465 m^2.

Exceptions:

1. In malls and arcades, auditoriums, single-tenant retail spaces, industrial facilities and arenas, where captive-key override is utilized, override time may exceed 2 hours.
2. In malls and arcades, auditoriums, single-tenant retail spaces, industrial facilities and arenas, the area controlled may not exceed 1860 m^2.

6.5.2.2.2.2 **Holiday scheduling.** If an automatic time switch control device is installed in accordance with Section 6.5.2.2.2, Item 1, it shall incorporate an automatic holiday scheduling feature that turns off all loads for at least 24 hours, then resumes the normally scheduled operation.

Exception: Retail stores and associated malls, restaurants, grocery stores, mosques, theaters and other places of assembly.

6.5.2.2.3 **Guestrooms.** Guestrooms in hotels, motels, boarding houses or similar buildings shall have at least one master switch at the main entry door that controls all permanently wired lighting fixtures and switched receptacles, except those in the bathroom(s). Suites shall have a control meeting these requirements at the entry to each room or at the primary entry to the suite.

6.5.2.3 **Exterior lighting controls.** Automatic switching or photocell controls shall be provided for all exterior lighting not intended for 24-hour operation. Automatic time switches shall have a combination seven-day and seasonal daylight program schedule adjustment.

Exceptions:

1. Lighting for covered vehicle entrance and exits from building or parking.
2. Where required for safety, security and eye adaptation.

6.5.3 **Tandem wiring.** The following luminaires located within the same area shall be tandem wired:

1. Fluorescent luminaires equipped with one, three or odd numbered lamp configurations, that are recess-mounted within 3 m center-to-center of each other.
2. Fluorescent luminaires equipped with one, three or any other odd-numbered lamp configuration that are pendant- or surface-mounted within 305 mm edge-

to-edge of each other.

Exceptions:

1. Where electronic high-frequency ballasts are used.
2. Luminaires on emergency circuits.
3. Luminaires with no available pair in the same area.

6.5.4 **Exit signs.** Internally illuminated exit signs shall not exceed 5 Watts per side.

6.5.5 **Interior lighting power requirements.** A building complies with this section if its total connected lighting power calculated under Section 6.5.5.1 is no greater than the interior lighting power calculated under Section 6.5.5.2 (only luminaires with minimum efficacy 45 lm/w and lamps with minimum efficacy 65 lm/w should be used).

6.5.5.1 **Total connected interior lighting power.** The total connected interior lighting power (Watts) shall be the sum of the watts of all interior lighting equipment as determined in accordance with Sections 6.5.5.1.1 through 6.5.5.1.4.

Exceptions: The connected power associated with the following lighting equipment is not included in calculating total connected lighting power.

1. Specialized medical, dental and research lighting.
2. Professional sports arena playing field lighting.
3. Display lighting for exhibits in galleries, museums and monuments.
4. Guest room lighting in hotels, motels, boarding houses or similar buildings.
5. Emergency lighting automatically off during normal building operation.

6.5.5.1.1 **Screw lampholders.** The wattage shall be the maximum labeled wattage of the luminaire.

6.5.5.1.2 **Low-voltage lighting.** The wattage shall be the specified wattage of the transformer supplying the system.

6.5.5.1.3 **Other luminaires.** The wattage of all other lighting equipment shall be the wattage of the lighting equipment verified through data furnished by the manufacturer or other approved sources.

6.5.5.1.4 **Line-voltage lighting track and plug-in busway.** The wattage shall be the greater of the wattage of the luminaires determined in accordance with Sections 6.5.5.1.1 through 6.5.5.1.3 or 98 W/linear m.

6.5.5.2 **Interior lighting power.** The interior lighting power shall be calculated using Section 6.5.5.2.1 or 6.5.5.2.2 as applicable.

6.5.5.2.1 **Entire building method.** Under this approach, the interior lighting power (Watts) is the value from Table 6.5.5.2 for the building type times the conditioned floor area of the entire building. The interior lighting power (Watts) shall not be increased by the allowances contained in the footnotes of Table 6.5.5.2 when using the entire building method.

6.5.5.2.2 **Tenant area or portion of building method.** The total interior lighting power (Watts) is the sum of all interior lighting powers for all areas in the building covered in this permit. The interior lighting power is the conditioned floor area for each area type listed in Table 6.5.5.2 times the value from Table 6.5.5.2 for that area. For the purposes of this method, an “area” shall be defined as all continuous spaces that accommodate or are associated with a single area type as listed in Table 6.5.5.2. When this method is used to calculate the total interior lighting power for an entire building, each area type shall be treated as a separate area.

6.5.6 **Exterior lighting.** When the power for exterior lighting is supplied through the energy service to the building, all exterior lighting, other than low-voltage landscape lighting, shall have a source efficacy of at least 45 lumens per Watt.

Exception: Where approved because of historical, safety, signage or emergency considerations.

6.5.7 **Electrical energy consumption.** In buildings having individual dwelling units, provisions shall be made to determine the electrical energy consumed by each tenant by separately metering individual dwelling units.

TABLE 6.5.5.2
INTERIOR LIGHTING POWER

Building or Area Type	Entire Building (W/m^2)	Tenant Area or Portion of Building (W/m^2)
Auditorium	Not Applicable	19.4
Automotive facility	9.7	Not Applicable
Bank/financial institution [a]	Not Applicable	16.1
Classroom/lecture hall [b]	Not Applicable	15.1
Convention, conference or meeting center [a]	12.9	14.0
Corridor, restroom, support area	Not Applicable	9.7
Courthouse/town hall	12.9	Not Applicable
Dining [a]	Not Applicable	9.7
Dormitory	10.8	NA
Exercise center [a]	10.8	9.7
Exhibition hall	Not Applicable	14.0
Grocery store [c]	16.1	17.2
Gymnasium playing surface	Not Applicable	15.1
Hotel function [a]	10.8	14.0
Industrial work, < 6.1 m ceiling height	Not Applicable	12.9
Industrial work, ≥ 6.1 m ceiling height	Not Applicable	18.3
Kitchen	Not Applicable	12.9
Library [a]	14.0	18.3
Lobby—hotel [a]	Not Applicable	11.8
Lobby—other [a]	Not Applicable	14.0
Mall, arcade, or atrium	Not Applicable	6.5
Medical and clinical care [b, d]	12.9	12.9
Motel	10.8	Not Applicable
Multifamily	7.5	Not Applicable
Museum [b]	11.8	10.8
Office [b]	10.8	11.8
Parking garage	3.02	Not Applicable
Penitentiary	10.8	Not Applicable
Police/fire station	10.8	Not Applicable
Post office	11.8	Not Applicable
Religious worship [a]	14.0	25.8
Restaurant [a]	17.2	9.7
Retail sales, wholesale showroom [c]	16,1	18.3
School	12.9	Not Applicable
Storage, industrial and commercial	8.6	8.6
Theaters—motion picture	12.9	12.9
Theaters—performance [a]	17.2	28.0
Transportation	10.8	Not Applicable
Other	6.5	10.8

1 m = 3.2808 ft, To obtain watts per square foot multiply watts per m^2 by 0.0929

a Where lighting equipment is specified to be installed for decorative appearances in addition to lighting equipment specified for general lighting and is switched or dimmed on circuits different from the circuits for general lighting, the smaller of the actual wattage of the decorative lighting equipment or 10.8 w/m^2 times the area of the space that the decorative lighting equipment is in shall be added to the interior lighting power determined in accordance with this line item.

b Where lighting equipment is specified to be installed to meet requirements of visual display terminals as the primary viewing task, the smaller of the actual wattage of the lighting equipment or 3.76W/m^2 times the area of the space that the lighting equipment is in, shall be added to the interior lighting power determined in accordance with this line item.

c Where lighting equipment is specified to be installed to highlight specific merchandise in addition to lighting equipment specified for general lighting and is switched or dimmed on circuits different from the circuits for general lighting, the smaller of the actual wattage of the lighting equipment installed specifically for merchandise, or 17.22W/m^2 times the area of the specific display, or 42.0W/m^2 times the actual case or shelf area for displaying and selling fine merchandise such as jewelry, fine apparel and accessories, or china and silver, shall be added to the interior lighting power determined in accordance with this line item.

d Where lighting equipment is specified to be installed, the smaller of the actual wattage of the lighting equipment, or 10.76W/m^2 times the area of the emergency, recovery, medical supply and pharmacy space shall be added to the interior lighting power determined in accordance with this line item.

SECTION 6.6
TOTAL BUILDING PERFORMANCE

6.6.1 **General.** The proposed design complies with this section where annual energy costs of the proposed design as determined in accordance with Section 6.6.3 do not exceed those of the standard design as determined in accordance with Section 6.6.4.

6.6.2 **Analysis procedures.** Sections 6.6.2.1 through 6.6.2.8 shall be applied in determining total building performance.

6.6.2.1 **Energy analysis.** Annual (8,760 hours) energy costs for the standard design and the proposed design shall each be determined using the same approved energy analysis simulation tool.

6.6.2.2 **Climate data.** The climate data used in the energy analysis shall cover a full calendar year (8,760 hours) and shall reflect approved coincident hourly data for temperature, solar radiation, humidity and wind speed for the building location.

6.6.2.3 **Energy rates.** The annual energy costs shall be estimated using energy rates published by the serving energy supplier and which would apply to the actual building or the SEC (Saudi Electric Company) rates which would apply to the actual building.

6.6.2.4 **Nondepletable energy.** Nondepletable energy such as solar energy or geothermal energy collected off site shall be treated and priced the same as purchased energy. Energy from nondepletable energy sources collected on site shall be omitted from the annual energy cost of the proposed design. The analysis and performance of any nondepletable energy system shall be determined in accordance with accepted engineering practice using approved methods.

6.6.2.5 **Building operation.** Building operation shall be simulated for a full calendar year (8760 hours). Operating schedules shall include hourly profiles for daily operation and shall account for variations between weekdays, weekends, holidays, and any seasonal operation. Schedules shall model the time-dependent variations of occupancy, illumination, receptacle loads, thermostat settings, mechanical ventilation, HVAC equipment availability, service hot water usage, and any process loads.

6.6.2.6 **Simulated loads.** The following systems and loads shall be modeled in determining total building performance: heating systems, cooling systems, fan systems, lighting power, receptacle loads, and process loads that exceed 10 W/m^2 of floor area of the room or space in which the process loads are located.

Exception: Systems and loads serving required emergency power only.

6.6.2.7 **Service water-heating systems.** Service water-heating systems that are other than combined service hot water/space-heating systems shall be omitted from the energy analysis provided all requirements in Section 6.4 have been met.

6.6.2.8 **Exterior lighting.** Exterior lighting systems shall be the same as in the standard and proposed designs.

6.6.3 **Determining energy costs for the proposed design.** Building systems and loads shall be simulated in the proposed design in accordance with Sections 6.6.3.1 and 6.6.3.2.

6.6.3.1 **HVAC and service water-heating equipment.** All HVAC and service water-heating equipment shall be simulated in the proposed design using capacities, rated efficiencies and part-load performance data for the proposed equipment as provided by the equipment manufacturer.

6.6.3.2 **Features not documented at time of permit.** If any feature of the proposed design is not included in the building permit application, the energy performance

of that feature shall be assumed to be that of the corresponding feature used in the calculations required in Section 6.6.4.

6.6.4 **Determining energy costs for the standard design.** Sections 6.6.4.1 through 6.6.4.7 shall be used in determining the annual energy costs of the Standard design.

6.6.4.1 **Equipment efficiency.** The space-heating, space-cooling, service water-heating, and ventilation systems and equipment shall meet, but not exceed, the minimum efficiency requirements of Sections 6.3 and 6.4.

6.6.4.2 **HVAC system capacities.** HVAC system capacities in the standard design shall be established such that no smaller number of unmet heating and cooling load hours and no larger heating and cooling capacity safety factors are provided than in the proposed design.

6.6.4.3 **Envelope.** The performance of elements of the thermal envelope of the standard design shall be determined in accordance with the requirements of Section 6.2.2 as applicable.

6.6.4.4 **Identical characteristics.** The heating/cooling system zoning, the orientation of each building feature, the number of floors and the gross envelope areas of the standard design shall be the same as those of the proposed design except as modified by Section 6.6.4.5 or 6.6.4.6.

Exception: Permanent fixed or movable external shading devices for windows and glazed doors shall be excluded from the standard design.

6.6.4.5 **Window area.** The window area of the standard design shall be the same as the proposed design, or 35 percent of the above-grade wall area, whichever is less, and shall be distributed in a uniform pattern equally over each building facade.

6.6.4.6 **Skylight area.** The skylight area of the standard design shall be the same as the proposed design, or 3 percent of the gross area of the roof assembly, whichever is less.

6.6.4.7 **Interior lighting.** The lighting power for the standard design shall be the maximum allowed in accordance with Section 6.5.4. Where the occupancy of the building is not known, the lighting power density shall be 16.1 W/m^2.

6.6.5 **Documentation.** The energy analysis and supporting documentation shall be prepared by a authorized design professional where required by the statutes of the jurisdiction in which the project is to be constructed. The information documenting compliance shall be submitted in accordance with Sections 6.6.5.1 through 6.6.5.4.

6.6.5.1 **Annual energy use and associated costs.** The annual energy use and costs by energy source of the standard design and the proposed design shall be clearly indicated.

6.6.5.2 **Energy-related features.** A list of the energy-related features that are included in the proposed design and on which compliance with the provisions of the code are claimed shall be provided to the code official. This list shall include and prominently indicate all features that differ from those set forth in Section 6.6.4 and used in the energy analysis between the standard design and the proposed design.

6.6.5.3 **Input and output report(s).** Input and output report(s) from the energy analysis simulation program containing the complete input and output files, as applicable.

The output file shall include energy use totals and energy use by energy source and end-use served, total hours that space conditioning loads are not met and any errors or warning messages generated by the simulation tool as applicable.

6.6.5.4 **Written explanation(s).** An explanation of any error or warning messages appearing in the simulation tool output shall be provided in a written, narrative format.

6.6.5.5 **Power factor improvement.** Where the power factor of the electrical system in the building is less than 0.85 then certain measures shall be taken, so that the drawn current should not exceed the necessary value required to provide the sufficient active power needed to run the electrically operated equipment in the building.

Such measures are shown in the section 8.1 SBC 401.

It is worthy to indicate herewith the importance of avoiding harmonics distortion as shown in the same section, to achieve optimum energy conservation.

CHAPTER 7
CLIMATE MAPS

SECTION 7.1
GENERAL

7.1.1 **Scope.** The criteria of this chapter is to establish design conditions based on Chapters 4, 5 and 6, as applicable.

SECTION 7.2
DEGREE DAYS

7.2.1 **General.** The degree days for use in Table 2.2.1 shall be selected for the nearest weather station from Saudi Arabia map in Figure 7.2.1. Degree Days (DD) values are given in Table 2.2.2.



Fig. 7.2.1 Saudi Arabia Map showing the weather stations.

REFERENCED STANDARDS

These are the standards referenced within SBC 601. The standards are listed herein by the promulgating agency of the standard, the standard identification, the effective date and title. The application of the referenced standards shall be as specified in SBC.

1. AAMA, 101/I.S.2—97, Voluntary Specifications for Aluminum, Vinyl (PVC) and Wood Windows and Glass Doors, American Architectural Manufacturers Association, 1827 Walden Office Square, , Suite 104, Schaumburg, IL 60173-4268.
2. AAMA, 101/I.S.2/NAFS—02, Voluntary Performance Specification for Windows, Skylights and Glass Doors, American Architectural Manufacturers Association, 1827 Walden Office Square, , Suite 104, Schaumburg, IL 60173-4268.
3. AMCA, 500—89, Test Methods for Louvers, Dampers, and Shutters, Air Movement and Control Association International, 30 West University Drive, Arlington Heights, IL 60004-1806.
4. ANSI, Z21.10.3—98, Gas Water Heaters, Volume III - Storage Water Heaters with Input Ratings Above 75,000 Btu per Hour, Circulating Tank and Instantaneous—with Addenda Z21.10.3a-99, American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.
5. ANSI, Z21.13—99, Gas-Fired Low-Pressure Steam and Hot Water Boilers, American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.
6. ANSI, Z21.47—00, Gas-Fired Central Furnaces—with Addenda Z21.47a-2000, American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.
7. ANSI, Z21.56—98, Gas-Fired Pool Heaters—with Z21.56a—with Addenda-1999, American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.
8. ANSI, Z83.8—96, Gas Unit Heaters—with Addendum Z83.8a-1997, American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036
9. ANSI, Z83.9—96, Gas-fired Duct Furnaces, American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.
10. ARI, 210/240—94, Unitary Air-Conditioning and Air-Source Heat Pump Equipment, Air Conditioning and Refrigeration Institute, 4301 North Fairfax Drive, Suite 200, Arlington, VA 22203.
11. ARI, 310/380—93, Standard for Packaged Terminal Air-Conditioning and Heat Pumps, Air Conditioning and Refrigeration Institute, 4301 North Fairfax Drive, Suite 200, Arlington, VA 22203.
12. ARI, 325—98, Ground Water-Source Heat Pumps, Air Conditioning and Refrigeration Institute, 4301 North Fairfax Drive, Suite 200, Arlington, VA 22203.
13. ARI, 340/360—2000, Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment, Air Conditioning and Refrigeration Institute, 4301 North Fairfax Drive, Suite 200, Arlington, VA 22203.
14. ARI, 365—94, Commercial and Industrial Unitary Air-Conditioning Condensing Units, Air Conditioning and Refrigeration Institute, 4301 North Fairfax Drive, Suite 200, Arlington, VA 22203.
15. ARI, 460-94, Remote Mechanical-Draft Air-Cooled Refrigerant Condensers, Air Conditioning and Refrigeration Institute, 4301 North Fairfax Drive, Suite 200, Arlington, VA 22203.
16. ARI, 550/590—98, Water Chilling Packages Using the Vapor Compression Cycle, Air Conditioning and Refrigeration Institute, 4301 North Fairfax Drive, Suite 200, Arlington, VA 22203.
17. ARI, 560—92, Absorption Water Chilling and Water Heating Packages, Air Conditioning and Refrigeration Institute, 4301 North Fairfax Drive, Suite 200, Arlington, VA 22203.

18. ARI, 13256-1 (1998), Water-source Heat Pumps - Testing and Rating for Performance - Part 1: Water-to-Air and Brine-to-Air Heat Pumps, Air Conditioning and Refrigeration Institute, 4301 North Fairfax Drive, Suite 200, Arlington, VA 22203.
19. ASHRAE, 136—1993 (RA 2001), A Method of Determining Air Change Rates in Detached Dwellings, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.
20. ASHRAE, 146-1998, Testing and Rating Pool Heaters, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.
21. ASHRAE, 13256-1 (1998), Water-source Heat Pumps - Testing and Rating for Performance - Part 1: Water-to-Air and Brine-to-Air Heat Pumps, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.
22. ASHRAE, 55—1992, Thermal Environmental Conditions for Human Occupancy, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.
23. ASHRAE, 90.1—2001, Energy Standard for Buildings Except Low-Rise Residential Buildings, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.
24. ASHRAE, ASHRAE—1999, HVAC Applications Handbook-1999, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.
25. ASHRAE, ASHRAE—2001, Fundamentals Handbook- 2001, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.
26. ASHRAE, ASHRAE—2000, HVAC Systems and Equipment Handbook-2000, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.
27. ASME, A112.18.1-2000, Plumbing Fixture Fittings, American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.
28. ASME, PTC 4.1 – 1964, Steam Generating Units, American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.
29. ASTM, C 236—93e1, Standard Test Method for Steady-State Thermal Performance of Building Assemblies by Means of a Guarded Hot Box, ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2859.
30. ASTM, C 518—98, Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus, ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2859.
31. ASTM, C 976 - 90(1996)96e1, Standard Test Method for Thermal Performance of Building Assemblies by Means of a Calibrated Hot Box, ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2859.
32. ASTM, E 96—00, Standard Test Methods for Water Vapor Transmission of Materials, ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2859.
33. ASTM, E 283—99, Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors Under Specified Pressure Differences Across the Specimen, ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2859.
34. ASTM, E 779—99, Standard Test Method for Determining Air Leakage Rate by Fan Pressurization, ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2859.
35. CTI, STD-201 (1996), Certification Standard for Commercial Water Cooling Towers, Cooling Technology Institute, 2611 FM 1960 West, Suite H-200, Houston, TX 77068-3730.
36. CTI, ATC-105 (1997), Acceptance Test Code for Water Cooling Towers, Cooling Technology Institute, 2611 FM 1960 West, Suite H-200, Houston, TX 77068-3730.

37. DOE, 10 CFR Part 430, Subpart B, Appendix E (1998) Uniform Test Method for Measuring the Energy Consumption of Water Heaters, U.S. Department of Energy, c/o Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-9325.
38. DOE, 10 CFR Part 430, Subpart B, Appendix N (1998) Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers, U.S. Department of Energy, c/o Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-9325.
39. DOE, 10 CFR Part 430, Subpart B, Test Procedures (1998) Energy Conservation Program for Consumer Products, U.S. Department of Energy, c/o Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-9325.
40. DOE, ORNL/Sub-86-72143/1-88, Building Foundation Design Handbook, U.S. Department of Energy, c/o Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-9325.
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